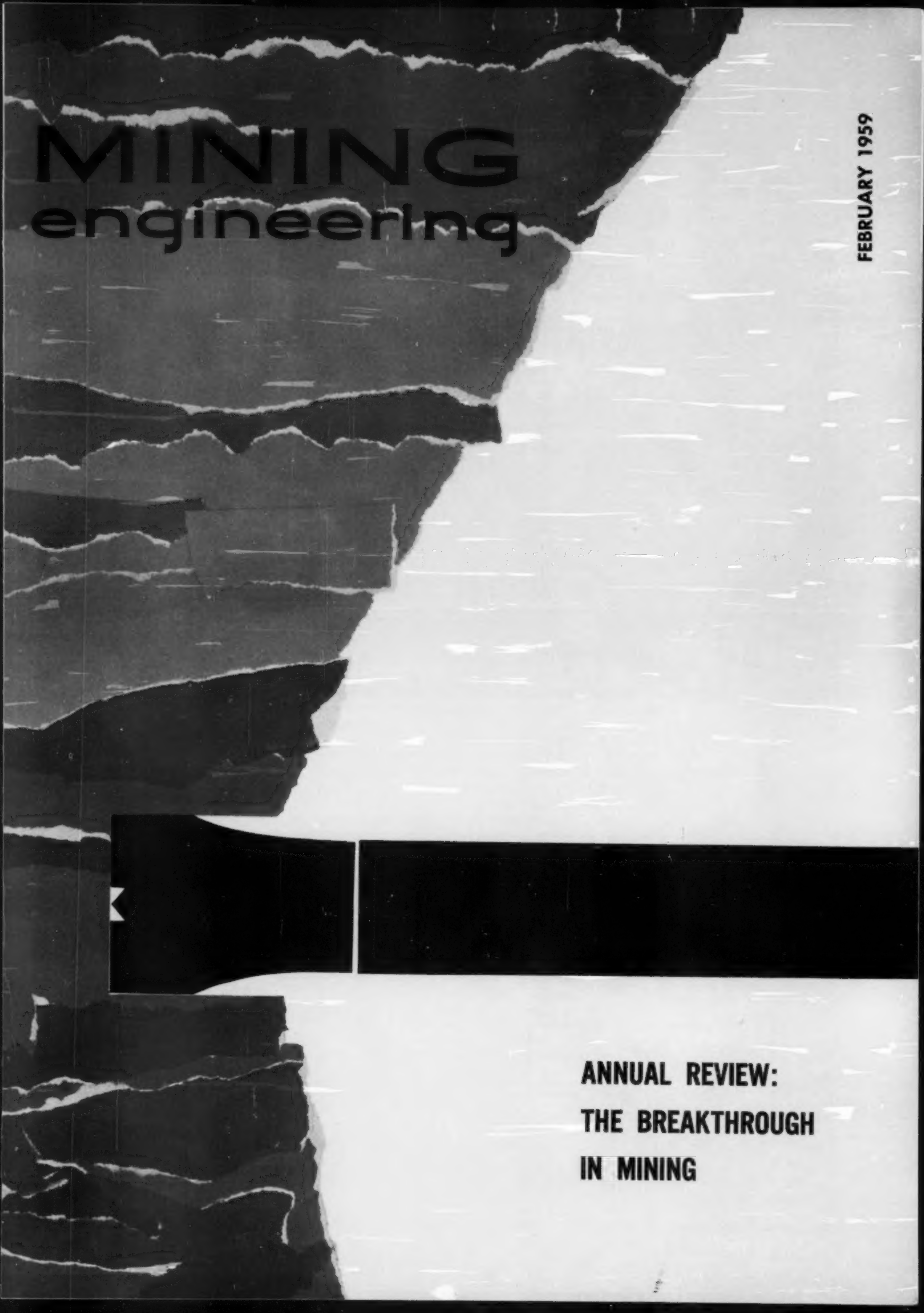
MINING engineering

FEBRUARY 1959



ANNUAL REVIEW:
THE BREAKTHROUGH
IN MINING

COMING EVENTS

Feb. 15-19, AIME Annual Meeting, Sheraton-Palace, St. Francis, Sir Francis Drake Hotels, San Francisco.

Feb. 23-27, Fluidized Reactor Course, University of Arizona, Tucson.

February, AIME Lima, Peru, Section, subject: panel review of Peruvian Geology, Lima, Peru.

Mar. 1-4, Canadian Prospectors & Developers Assn., annual meeting and convention, Royal York Hotel, Toronto.

Mar. 2-3, Fluidized Reactor Symposium, University of Arizona, Tucson, Ariz.

Mar. 16-19, 11th Western Metal Congress, American Society for Metals, Los Angeles.

Apr. 5-10, EJC 1959 Nuclear Congress, Public Auditorium, Cleveland.

Apr. 13-15, CIM, annual meeting, Queen Elizabeth Hotel, Montreal.

Apr. 16-18, AIME Pacific Northwest Regional Conference, Olympic Hotel, Seattle.

Apr. 18, AIME Colorado MBD Subsection, Broadmoor Hotel, Colorado Springs, Colo.

Apr. 20-22, Third Rock Mechanics Symposium, tri-sponsors: Colorado School of Mines, Pennsylvania State University, and University of Minnesota; Colorado School of Mines, Golden, Colo.

May 8-10, Fourth Annual Uranium Symposium, AIME Uranium Section, Moab, Utah.

May 11-14, American Mining Congress, Coal Show, Cleveland.

June 15 (approx.) AIME Pittsburgh Section—SME Coal Division, joint meeting, Waynesburg, Pa.

June 28-July 1, Rocky Mountain Coal Mining Inst., annual meeting, Antlers Hotel, Colorado Springs, Colo.

Sep. 14-17, American Mining Congress, Metal Mining & Industrial Minerals Convention, Denver.

Sept. 24-26, SME Industrial Minerals and Coal Divisions, joint meeting, Bedford Springs, Pa.

Oct. 8-10, Exploration Drilling Symposium, tri-sponsors: Colorado School of Mines, Pennsylvania State University, and University of Minnesota; Pennsylvania State University, University Park, Pa.

Oct. 27-29, 1959 AIME-ASME Joint Solid Fuels Conference, Netherland-Hilton Hotel, Cincinnati.

Nov. 9-12, Society of Exploration Geophysicists, annual meeting, Biltmore Hotel, Los Angeles.

Dec. 7, AIME Arizona Section, annual meeting, Tucson, Ariz.

SOCIETY OF AIME MINING ENGINEERS

MINING engineering

Vol. 11 NO. 2 **FEBRUARY 1959**

COVER *This month cover artist Herb McClure symbolizes the breakthrough in mining—through research—at the point where research begins to bear fruit—where the bit meets the rock.*

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MEN AVAILABLE

Mining Engineer, B.S., E.M. Experienced in Latin American mines with 12 years of surveying, sampling, ore reserve estimation, computing, and mapping; also familiar with industrial hygiene and safety, including supervision and administrative work. Fluent in Spanish. Will travel. M-456.

Mining Engineer, B.S., age 43. Chief mining engineer for 10 years with an iron ore company, both open pit and underground mines, in charge of 60-man engineering department. Previous 10 years spent as mining engineer. Experienced in exploration, development, and production. Prefer U. S. M-457.

Mining Engineer, E.M., age 37. Fourteen years experience in engineering and supervisory capacity, open pit and underground mining, mine exploration, milling, and industrial work. Some tunnel experience. Mine and mill plant construction experience. Prefer western U. S. M-458.

Exploration/Mining Engineer, B.S. in mining engineering, age 24. Working in exploration for bauxite in Latin America for nine months and assistant mine engineer in nonmetal mine as well as experience in metal mine. Experienced surveyor. Foreign or domestic service desired. M-459.

Mine Superintendent—Assistant Mine Superintendent, ACSM in mining, age 31. Graduate mining engineer with eight years underground experience in Canada, Latin America, and the Philippine Islands. Married, no children. Excellent knowledge of Spanish. Location, immaterial. M-405-San Francisco.

Production Manager (non-metallic mining) M.S. in mining engineering, age 41. Manager for six years of large non-metallic mining and manufacturing plant in Middle West for national company; seven years in mining and plant engineering with same company. Four years experience in copper mining; two years teaching mining engineering. Location, immaterial. M-924-Chicago.

General Manager, age 44, with university degrees. Recently general manager of division of large mining company. Particularly qualified in field of industrial minerals including technology, production, sales, administration, capital planning, economic analyses, new product and process development. Available immediately. M-460.

Exploration and Mining Geologist, B.S. in geology, age 36. Ten years experience in exploration and production, base metals and uranium, surface and underground. Employed by A.E.C., state geologic survey, large and small mining companies. Last six years in supervisory and administrative capacity. Experienced in report writing. Desire responsible position in exploration and mining western U. S. Presently employed; available with two weeks notice. M-461.

Mine Superintendent, mining engineering degree, age 40. For 20 years experienced in operating mines of many types throughout U. S. Well versed in modern mining trends including adaptation of diesel equipment underground. Experienced in mine and plant planning. Excellent safety record; demonstrated ability to handle labor of many types. Prefer western U. S. M-539-San Francisco.

General Manager or Assistant, B.S. in mining, age 41. Sixteen years of successful management in all phases of non-metallics from plant design and construction through operations, including labor and public relations, cost control methods, exploration, research, and sales. Prefer the west. M-398-San Francisco.

POSITIONS OPEN

Recent Graduate Mining Engineer, to work as staff assistant to manager of 300 tpd operations in northeastern New York. Will be in charge of mine and quarry, mapping, programming and exploration and will spend one half of time processing engineering and quality control. Salary open. W6963.

Assistant Chief Engineer, graduate in mining, civil, mechanical, or metallurgical engineering, with at least five years experience in mining or metallurgical operations, in structural design, stress analyses, and layout. Thorough knowledge of management of technical employes required. Must have ability to design, develop, and supervise the construction of production, control, and maintenance facilities for mine, mill, and community management departments. Salary commensurate with experience and ability. Location, mountain states. W6886.

Mining Engineer, preferably with some mining or supervisory experience, to take charge of writing, measuring, and calculating contracts with miners. Mine is a deep shaft operation, producing 800 tpd of chiefly silver ore from a number of steep, relatively narrow veins. Location, West. W6870S.

Project Engineer, Research Operations, M.S. degree preferred with undergraduate degree in mineral dressing (or other mineral engineering field) and graduate work in chemical or mechanical engineering. Will consider undergraduate training in chemical or mechanical engineering with graduate work in mineral engineering. Plus two to seven years experience in fields related to the mineral industry. Work will be primarily in research and development relating to fluid energy grinding and non-metallic minerals. Salary commensurate with training and experience. Location, upstate New York. W6826.

Project Manager, geologist, with considerable experience in planning a geological expedition and experience in searching for water. Should have temperament and personality to work with foreign diplomats. Foreign assignment. Salary, $25,000-$35,000 a year. Headquarters, eastern U. S. F6804.

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Now—what can it do for you? Here's the answer: The D8 has been thoroughly field tested on actual jobs. Several of the big new tractors have been at work constantly in every kind of material. Out of the statistics developed, both pushloading and bulldozing production figures are *up*.

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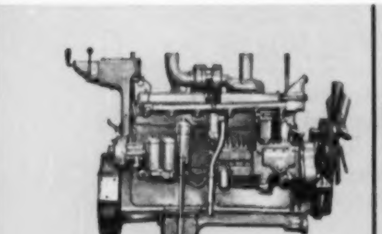
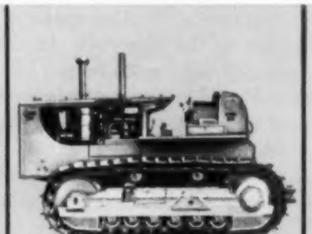


HORSEPOWER INCREASED 18%. The horsepower of the new D8 is up from 191 to 225 at the flywheel, from 155 to 180 at the drawbar. In addition, engine torque rise now is 20%, an increase of one-third. Over-all engine performance has been greatly improved by the addition of a turbocharger.



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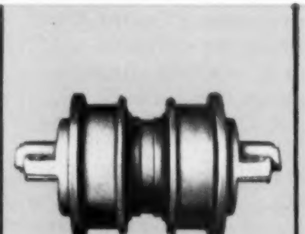

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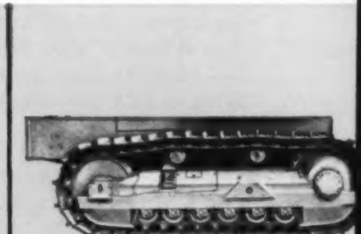

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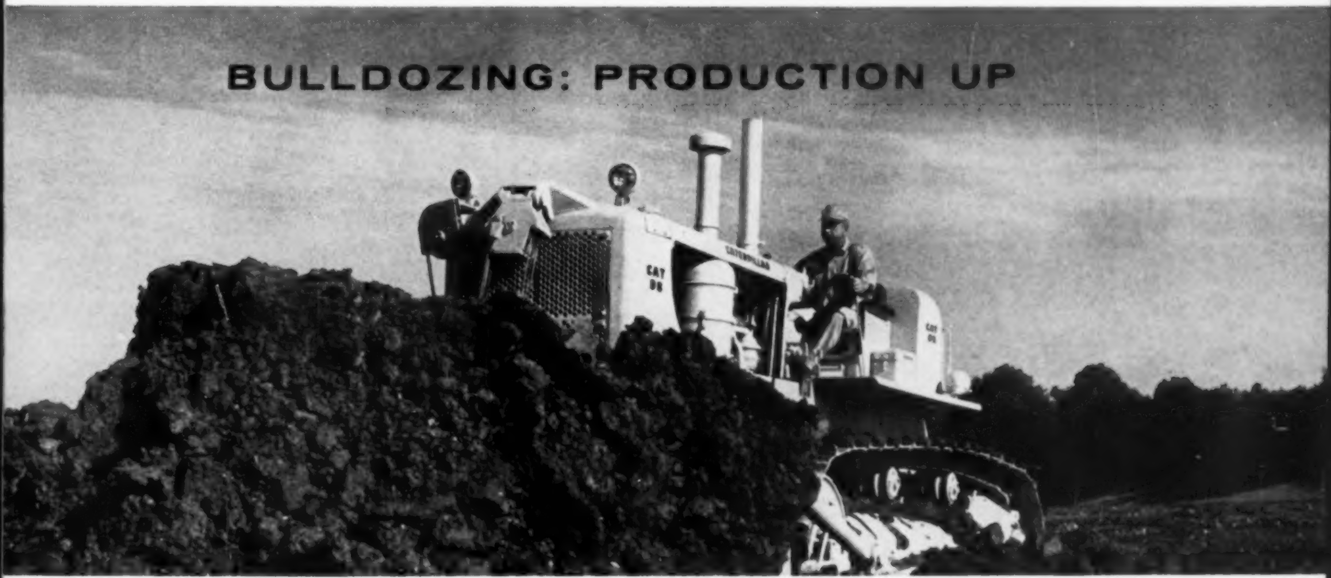

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DRY-TYPE AIR CLEANER. Here's still another major Caterpillar research development on the new D8—the new dry-type cleaner which removes 99.8% of dirt in the intake air, even under severe operating conditions. The new cleaner can be serviced in 5 minutes, costs a good deal less to use.

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Zeitschrift für Physikalische Chemie, Vol. 16, Nos. 3-6, published by *Akademische Verlagsgesellschaft m.b.H.*, order from Walter J. Johnson Inc., 111 Fifth Ave., New York 3, N.Y., $7.50, 1958.—The Simon Memorial Issue of the new series, Frankfurt edition, contains papers on isotopes; paramagnetic resonance and nuclear alignment, synthetic gems, and many other interesting subjects.

Houben-Weyl Methoden Der Organischen Chemie, Vol. 2, Part 2: Spezielle Chemische Methoden. Stickstoffverbindungen II. (Unwandlung Von Aminen) Stickstoffverbindungen III. 4th ed., edited by Eugen Mueller in collaboration with O. Bayer, H. Meerwein and K. Ziegler, order from *Walter J. Johnson Inc.*, 111 Fifth Ave., New York 3, N.Y., $37.20, 1958.

Automation and Management, by James R. Bright, *Div. of Research*, Harvard Business School, Soldiers Field, Boston 63, Mass., $10, 1958.—The first part deals with the evolutionary nature of production techniques in a comparison of two industries—electric light bulbs and shoes. The second part discusses managerial problems in designing and procuring automation programs. The last section gives a deeper exploration of maintenance, labor, sales, and management itself.

Motivation Research and Marketing Management, by Joseph W. Newman, *Div., of Research*, Harvard Business School, Soldiers Field, Boston 63, Mass., $7.50, 1957.—Specific examples explain this new field of the behavioral sciences in marketing. It focuses on ways of thinking and explores why our understanding of buying and consumption is so limited.

Performance and Development of Field Sales Managers, by Robert T. Davis, *Div., of Research*, Harvard Business School, Soldiers Field, Boston 63, Mass., $3.50, 1957.—A study of the first echelon of sales management with worthwhile techniques for the selection, training, and compensation of more competent managers.

Administration of Salaries and Intangible Rewards for Engineers and Scientists, by John W. Riegel, Publications Distribution Service, *University of Michigan*, Ann Arbor, Mich., 105, 84 pp., $6., 1958.—Two surveys in one volume devoted to needs, goals, and job satisfaction of engineers. The surveys are Reports Nos. 8 and 9 of The University of Michigan Bureau of Industrial Relations.

Industrial Carbon and Graphite, by the Soc. of Chemical Industry, London, published by *The Macmillan Co.*, N.Y., 630 pp., $25.75, 1958.—A symposium of over 60 papers at a conference sponsored by Soc. of Chemical Industry. The physical properties, manufacture, and industrial applications are discussed with rich information from England and Europe that is not available elsewhere.

Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, 34 vols., 500 pp. each, *Walter J. Johnson Inc.*, 111 Fifth Ave., New York 3, N.Y., $510.00.—Subjects covered include use of nuclear energy for purposes other than the generation of electricity, raw materials, possibility of controlled fusion, and many others.

State Publications

Salt in California, Bulletin 175, by William E. Ver Planck, *Div. of Mines*, Ferry Bldg., San Francisco 11, Calif., 168 pp., $3.25, 1958.

Sand and Gravel Resources of Cache Creek in Lake, Coluse, and Yolo Counties, Calif., in California Journal of Mines and Geology, by Ira E. Klein and Harold B. Goldman, *Div. of Mines*, Ferry Bldg., San Francisco 11, Calif., $1.00, 1958.

Age Determination of Some Granitic Rocks in California by the Potassium-Argon Method, Special Report 54, by C. H. Curtis, J. F. Evernden, and J. Lipson, *Div. of Mines*, Ferry Bldg., San Francisco 11, Calif., 50¢, 1958.

Studies of Devonian Algae, Vol. 53, No. 2 of Quarterly of the Colorado School of Mines, by J. Harlan Johnson and Kenji Konishi, *Colorado School of Mines*, Golden, Colo., 22 pp., 26 plates, 7 tables, 6 maps, $1.50, 1958.

An Annotated Bibliography on Coal, Vol. 54, No. 3 of Quarterly of the Colorado School of Mines, by Parke O. Yingst, *Colorado School of Mines*, Golden, Colo., 108 pp., $1, 1958.

Bloated Clay Aggregate, Its Production and Marketing Potential in Florida, Bulletin 98, by Merrill J. Roberts, *Florida Engineering and Industrial Experiment Station*, College of Engineering, University of Florida, Gainesville, Fla., 52 pp., 3 maps, 28 tables, 1 copy free, aditional copies $1.50, 1958.

Geology and Petrology of the Anvil Rock Sandstone of Southern Illinois, Circular 256, by M. E. Hopkins, *Div. of the Illinois State Geological Survey*, Urbana, Ill., 52 pp., gratis, 1958.

Oxidation of Coal, Report of Investigations 207, by G. R. Yohe, *Illionis State Geological Survey*, Urbana, Ill., 52 pp., 25¢, plus postage, 1958.

Water Sorption Properties of Homoionic Clay Minerals, Report of Investigations 208, by W. Arthur White, *Illinois State Geological Survey*, Urbana, Ill., 46 pp., 16 figs., 4 tables, 25¢, plus postage, 1958.

Age of the Springville Shale (Mississippian) of Southern Illinois, Circular 254, by Charles Collinson and Alan J. Scott, *Illinois State Geological Survey*, Urbana, Ill., 12 pp., gratis, 1958.

Conodonts from the Glen Dean Formation (Chester) of the Illinois Basin, Report of Investigations 209, by Carl R. Rexroad, *Illinois State Geological Survey*, Urbana, Ill., 28 pp., 25¢, 1958.

Petrographic and Coking Characteristics of Coal, Bulletin 84, by Charles E. Marshall, J. A. Harrison, J. A. Simon, and Margaret A. Parker, *Illinois State Geological Survey*, Urbana, Ill., 120 pp., 90 figs., 36 tables, 50¢, 1958.

Origin of Illinois Sand and Gravel Deposits, Industrial Minerals Notes No. 8, by J. E. Lamar and H. B. Willman, *Illinois State Geological Survey*, Urbana, Ill., 10 pp., gratis, 1958.

The Meramec-Chester and intro-Chester boundaries and associated strata in Indiana, Bulletin 12, by T. G. Perry and Ned M. Smith, *Indiana Geological Survey*, Publications Section, Indiana Dept. of Conservation, Indiana University, Bloomington, Ind., 110 pp., 6 pls., 1 fig., $2, 1958.

Map of Meramec-Chester and intra-Chester boundaries and associated strata in Indiana, *Indiana Geological Survey*, Publications Section, Indiana University, Bloomington, Ind., $1, 1958.

An Aeromagnetic and Geologic Reconnaissance Survey of Atkinson and Vicinity, Piscataquis County, Maine, GP & G Survey No. 2, by Lawrence A. Wing, *Maine Geological Survey*, State Geologist, Dept. of Economic Development, Augusta, Maine, 78¢, 1958.

An Aeromagnetic and Geologic Reconnaissance Survey of Portions of Penobscot, Hancock, and Washington, Counties, Maine, GP & G Survey No. 3, by Lawrence A. Wing, *Maine Geology Survey*, State Geologist, Dept. of Economic Development, Augusta, Maine, $4.65, 1958.

Maine Metal Mines and Prospects, Minerals Resources No. 3, by Arthur M. Hussey II, *Maine Geological Survey*, State Geologist, Dept. of Economic Development, Augusta, Maine, 88¢, 1958.

Placer Gold in Maine, *Maine Geological Survey*, State Geologist, Dept. of Economic Development, Augusta, Maine, gratis.

Study of Missouri Shales for Lightweight Aggregate, Report of Investigations No. 23, by P. G. Herold, P. Kurtz, Jr., T. J. Planje, and J. D. Plunkett, *Missouri Geological Survey and Water Resources*, State Geologist, P. O. Box 250, Rolla, Mo., 39 pp., 11 figs., 5 tables, 25¢, 1958.

Iron Ore Deposits in Montana, Information circular 13, by Victor C. DeMunck, *Montana Bureau of Mines and Geology*, Room 203-B, Main Hall, Montana School of Mines, Butte, Mont., 50 pp., gratis, 1958.

Progress Report on Clays of Montana, Information Circular 23, by Uuno M. Sahinen, Don C. Lawson, and Ralph I. Smith, *Montana Bureau of Mines and Geology*, Room 203-B, Main Hall, Montana School of Mines, Butte, Mont., gratis, 1958.

Practical Guide, Prospectors, Small-Mine Operators, Miscellaneous Contribution No. 13, by K. S. Stout, *Montana Bureau of Mines and Geology*, Room 203-B, Main Hall, Montana School of Mines, Butte, Mont., $1, 1955.

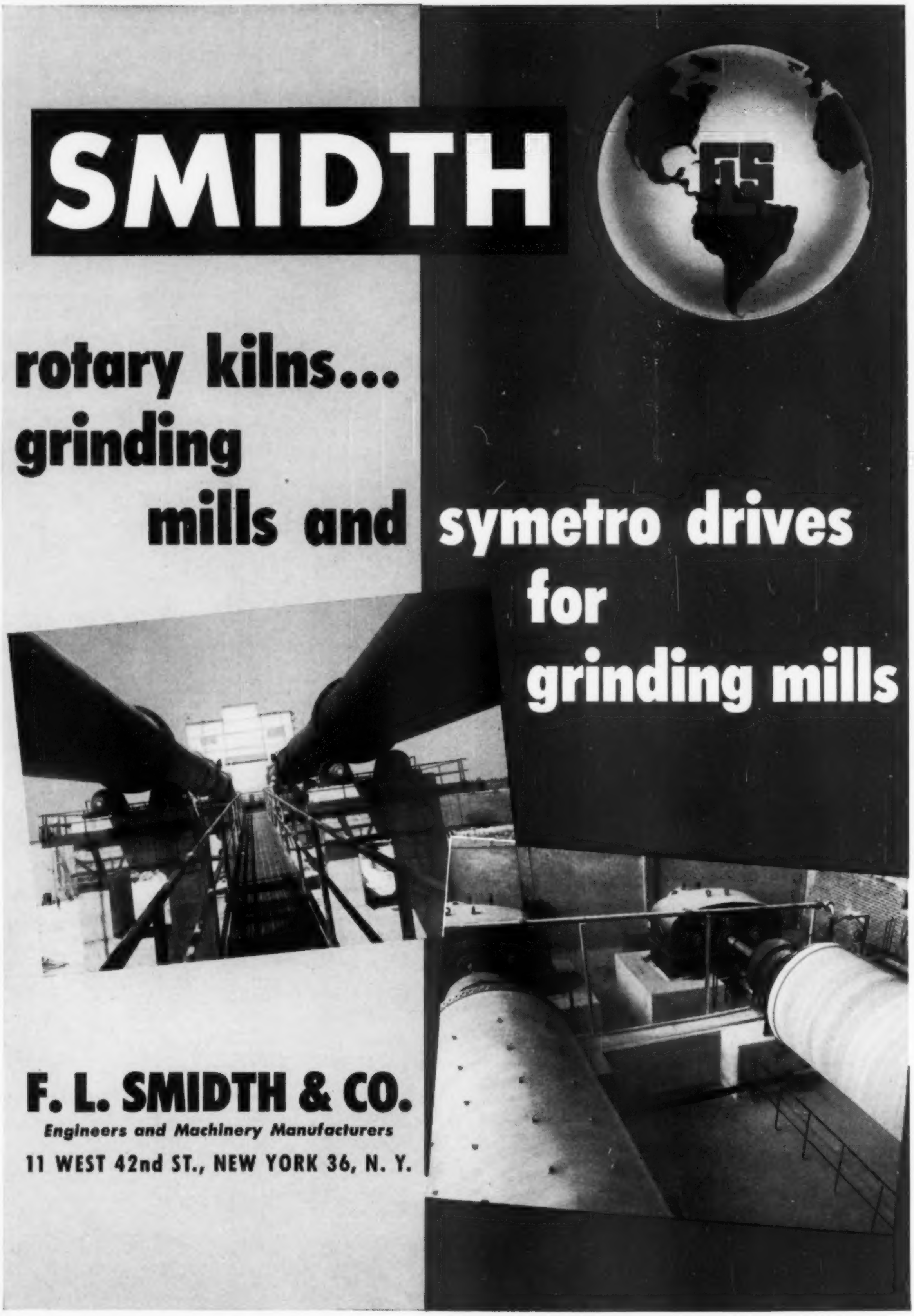
Geologic Map and sections of Georgetown thrust area, Granite and Deer Lodge Counties, Mont., Map. No. 1, by Glenn J. Poulter, *Montana Bureau of Mines and Geology*, Room 203-B, Main Hall, Montana School of Mines, Butte, Mont., 40¢, 1957.

Expandable Shale in the Great Falls Area, Montana, Information Circular 18, by U. M. Sahinen, *Montana Bureau of Mines and Geology*, Room 203-B, Main Hall, Montana School of Mines, Butte, Mont., gratis, 1957.

Directory of Montana geologists, Information Circular 19, by U. M. Sahinen, *Montana Bureau of Mines and Geology*, Room 203-B, Main Hall, Montana School of Mines, Butte, Mont., gratis, 1957.

Directory of known mining enterprises, Information Circular 20, by K. S. Stout and W. C. Ackerman, *Montana Bureau of Mines and Geology*, Room 203-B, Main Hall, Montana School of Mines, Butte, Mont., gratis, 1957.

(Continued on page 117)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BOOKS

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Iron Ore Deposits of Nevada, Bulletin 53, Part B, West-Central Nevada, by R. G. Reeves, F. R. Shawe, and V. E. Kral, *Nevada Bureau of Mines,* University of Nevada, Reno, Nev., $1.50 plus postage, 1958.

Geology of the Hanover Quadrangle, New Hampshire, by John B. Lyons, *New Hampshire State Planning and Development Commission,* State Office Bldg., Concord, N. H., 41 pp., $1, 1958.

Scenic Trips to the Geologic Past No. 3, Roswell-Capitan-Ruidoso and Bottomless Lakes Park, New Mexico, by J. E. Allen and F. E. Kottlowski, *State Bureau of Mines and Mineral Resources,* New Mexico Inst. of Mining and Technology, Socorro, N. M., 48 pp., 25¢, 1958.

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Washington 8, D. C.

Disorder in a crystalline condensed phosphate, No. 1278, by J. W. Gryder, G. Donnay, and H. M. Ondik, reprint from Acta Cryst., 11, 38-40, 1958.
The transition between the low- and the high-temperature form of sodium tripolyphosphate, No. 1279, by G. W. Morey, reprint from J. Am. Chem. Soc., 80, 775, 1958.
Crystal and twin structure of digenite, Cu_9S_5, No. 1280, by G. Donnay, J. D. H. Donnay, and G. Kullerud, reprinted from Am. Mineral, 43, 230-242, 1958.
A possible explanation of the δ_c separations in intermediate plagioclase, No. 1281, by F. Chayes, reprinted from Acta Cryst., 11, 323-324, 1958.

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Miners' Circular 48 Accidents from Falls of Roof and Coal in Bituminous-Coal Mines. Coal-Mine Accident Prevention Course, Section 2, 141 pp., 93 figs., 50¢, 1945.
RI 5415 History and Potentialities of the Cushing Oilfield, Creek County, Okla., 109 pp., 47 figs., $1.25, 1959.
IC 7843 Manganese Deposits in Western Arizona, 87 pp., 25 figs., 45¢.

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RI 5404 A study of the Feasibility of Hydraulic Transport of a Texas Lignite.
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RI 5411 Manganese Resources of the Batesville District, Ark. Part 2 of 3 Parts.
RI 5414 Auxiliary Ventilation of Continuous Miner Places.
IC 7833 Administration of the Federal Coal-Mine Safety Act, Calendar Year 1957.
IC 7835 Shaft-Sinking Methods and Costs at the T. L. Shaft, Eureka Corp. Ltd., Eureka, Nev.
IC 7836 Sulfur Dioxide—Its Chemistry and Removal From Industrial Waste Gases.
IC 7837 Open-Pit Mining Methods and Practices at the Chino Mines Div., Kennecott Copper Corp., Grant County, N. M.
IC 7838 Block Caving in Limestone at the Crestmore Mine, Riverside Cement Co., Riverside, Calif.
IC 7839 Determination of Low Concentrations of Methane in Coal-Mine-Air Samples by Infrared Absorption Spectrometry.
IC 7845 Recommended Safety Standards for Surface Auger Mining.
Mineral Trade Notes for June 1958. Special supplement 54 to Vol. 46, No. 6. Exploration and Development of Mineral Resources in French Equatorial Africa.

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7S Consumption of Copper and Copper-Base Alloy Mill Shapes and Forms, 24 pp., 20¢, 1958, Catalog No. C 3.24/13:954/MC-303
8T 1954 Censuses of Business, Manufactures, Mineral Industries, Company Statistics, 24 pp., 60¢, 1958, Catalog No. C 3.222:954/1
12T General Drawing Practice, MIL-STD-1A; May 23, 1958, 30 pp., 35¢, 1958. Catalog No. D 7.10:1A
22T Earned Degrees Conferred by Higher Educational Institutions, 1956-1957, 196 pp., $1.50, 1958, Catalog No. FS 5.4:527
26T Alaska, 1958-1959, 20¢, Catalog No. I 35.10/2:Al 1s/17/958-59
31T Directory of Post Offices, 800 pp., $2.50, 1958, Binders are available at $2.50 each, Catalog No. P 1.10/4:958
36T Handbook of Federal Regulations Applying to Transportation of Radioactive Materials, 48 pp., 25¢, 1958, Catalog No. Y 3.At 7:6T 68/958
United States Government Organization Manual, 791 pp., $1.50, Catalog No. GS 4. 109:958
29U Selected Annotated Bibliography of the Geology of Uraniferous and Radioactive Native Bituminous Substances, exclusive of Coals in the United States, pp. 177-203, map, 45¢, 1958, Catalog No. I 19.3:1059-D
Preparation of illustrations for reports of USGS, with brief descriptions of processes of reproduction, 70¢, Catalog No. I 19.2:Il 6

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Canadian Iron Ore and the North American Iron and Steel Industry Map MR1, *Dept. of Mines and Technology Surveys,* Mineral Resources Div., Ottawa, Ont., Canada, gratis, 1958.

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Record of Observations at the Magnetic Observatories, Agincourt and Meanook, 1936-1937, Vol. 17, No. 2, 33 pp., 25¢, Cat. No. M70-17/2.

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Mineral Information Bulletin MR 27, A Survey of the Iron Ore Industry in Canada During 1957, by T. H. Janes and R. B. Elver, 1958, 25¢.
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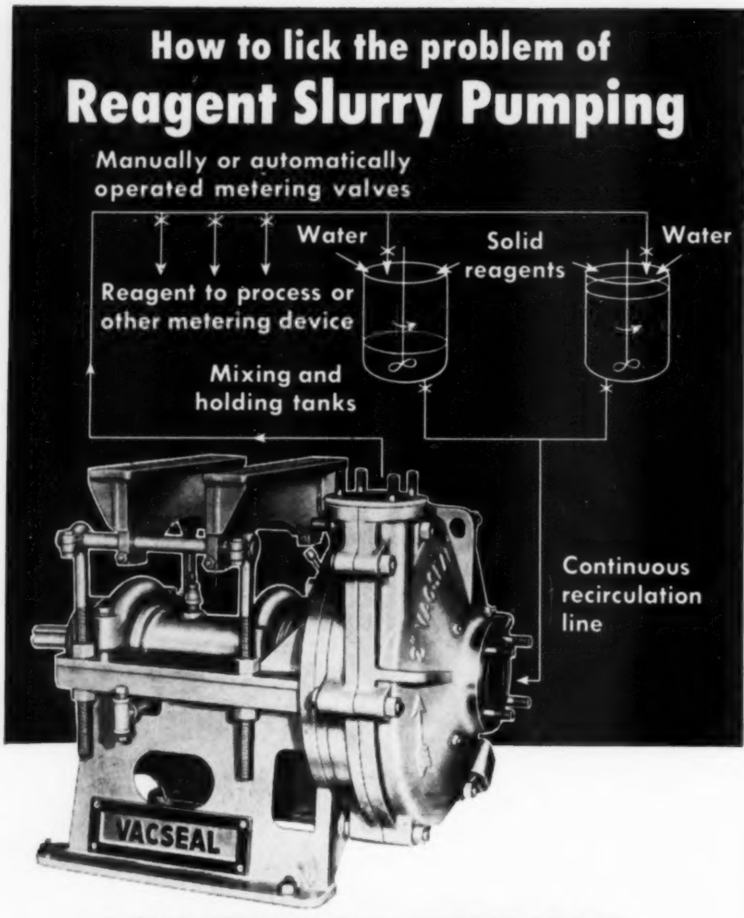
Bulletin No. 34, Regional Geology and Mineral Resources of the Olary Province, 7 shillings and sixpence.

Other Foreign Publications

The Geology of the Volta River Project, Bulletin No. 20, by W. B. Tevendale, *Ghana Geological Survey,* P.O. Box 98, Saltpond, Ghana, West Africa, 120 pp., 8 plates, 19 maps, 15 s. (Ghana currency) 1957.

(Continued on page 118)



Bollettino Del Servizio Geologico D'Italia, published annually by *Servizio Geologico d'Italia,* Libreria dello Stato, Piazza Verdi, 10, Roma, Italy, approx. $5.85 or 3600 Lira. Published in Italian.

International Strata Control Congress 1958, complete text of lectures given at the conference Oct. 14 to 16, 1958 in Leipzic, Germany; English edition can be ordered from *Helios Literatur-Vertriebs-GMBH,* Berlin-Borsigwalde, Germany; 21 reports, 319 pp., 256 illus., $17.50 credited to the account Nr. 74435 at the Bank fur Handel and Industrie, Berlin, 1958.

Guss im Bergbau (Ferrous castings in mining practice) with contributions by K. Repetzki and W. Stumpe, request on letterhead from *Zentrale fur Gussverwendung,* Sohnstrasse 70, P.O. Box 1033, Dusseldorf, Germany; 48 pp. illustrated, published in German, 1958.

Technical Reports No. 2, *Dept. of Mines,* Tasmania, Part I, Geological Reports; Part II, Mining; Part III, Ore Dressing Investigations; 176 pp., 34 plates, approx. 75¢, 1958.

ABSTRACTS

In This Issue: *The following abstracts of papers in this issue are reproduced for the convenience of members who wish to maintain a reference card file and for the use of librarians and abstracting services. At the end of each abstract is given the proper permanent reference to the paper for bibliography purposes.*

Free World Nations Must Consolidate on Metal Requirements by *Charles Will Wright*—The author suggests establishing a committee, headed by the U.S. Bureau of Mines and representatives of the metal industries, to work out mineral supply problems within the U.S. and the Free World nations. He urges expansion of USBM representation abroad and stresses the need for a foreign fact-finding service attached to the Bureau. **Ref.: MINING ENGINEERING, February 1959, p. 165.**

Trends in Real Prices of Representative Mineral Commodities, 1890-1957 by *C. W. Merrill* (TP 4792K)—Price records of seven representative mineral commodities for the 68-year period 1890-1957 have been compiled and analyzed for significant trends. When these records are reduced to *real* prices in terms of dollars of constant purchasing power or to the purchasing power of industrial wages at average rates, a substantial overall fall in prices is revealed. This downtrend contradicts the widely held concept that heavy drafts on a mineral resource must lead to scarcity, reflected in rising prices. **Ref.: (MINING ENGINEERING, February 1959), AIME Trans., 1959, vol. 214, p. 155.**

Trends in Metal Consumption and Prices Steel, Copper, Lead, Zinc by *Nathaniel Arbiter*—This article reports the findings of a statistical study of steel, copper, lead, and zinc consumption and prices over a large part of this century. It will be shown that per capita consumption can be correlated adequately by linear trend lines. The assumptions and uncertainties in developing the trends are considered. It will also be shown that although actual price forecasting is impossible because of currency fluctuations, the price ratios for copper, lead, and zinc relative to steel permit definition of a normal price for each of these metals relative to a prevailing steel price. **Ref.: MINING ENGINEERING, February 1959, p. 160.**

The Vital Role of Metals in a Nation's Industrial and Military Welfare by *Charles Will Wright*—With steadily increasing requirements for civilian use as well as for defense, the U. S. is becoming more dependent on foreign sources for many essential metals. Until now it has been possible

(Continued on page 121)

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MINING EQUIPMENT
Modernize The Cost-Less Way for QUICKER PROFITS
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The Automatic Door operates mechanically by weight of car on activating levers. Air power operation may be had where desirable. Operates at any trip speed. Two doors provide air lock.
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Hydraulically driven from a gear type pump directly connected to dusting motor. Travels up to 2 miles per hour. Wet or dry dusting. Height on tires 23½". Turning radius, its own length.
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Clean entire track area mechanically in one pass—no costly hand labor, no dozers or loaders required—hydraulic controls throughout. "Pays for itself in one sweep through mine." Now used in coal—iron—copper—lead—potash and salt mines.
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ABSTRACTS

Continued from page 118

to import these metals at favorable prices. But other countries are awakening to the benefits of industrialization and are expanding their manufacturing facilities. Their demands on world metal resources will intensify, and the U. S. may soon find it difficult to acquire the imports needed for its industries. Our greatest weakness is that at present there are not enough known commercial deposits within our borders to satisfy increasing demands. **Ref.: MINING ENGINEERING, February 1959, p. 167.**

Effect of Soil Contamination on Geochemical Prospecting in the Coeur d'Alene District, Idaho by *F. C. Canney* (TP 4784L)—Contamination is a hazard in most geochemical surveys that can interfere by creating spurious anomalies or by raising the background to such a level that ture anomalies are no longer easily detectable. The areal extent of contamination patterns surrounding the lead and zinc smelters in the Coeur d'Alene district were investigated by determining the lead and zinc content of profile soil samples collected from 46 sites mostly within a 5-mile radius of the smelter. Within the area studied, the degree of contamination below a depth of 6 in. is not sufficiently great to interfere seriously with the use of geochemical techniques; but to provide a safety factor, a soil-sampling depth of 10 in. is recommended. **Ref.: (MINING ENGINEERING, February 1959) AIME Trans., 1959, vol. 214, p. 205.**

Gravity Methods Clean Extreme Fine Sizes of Bituminous Coal by *H. B. Charmbury* and *D. R. Mitchell* (TP 4787F)—In recent years slimes have been effectively removed by low-pressure cyclones, which are economically sound for those plants where an underflow product of marketable grade can be obtained. The possibility of using high-pressure cyclones as concentrators for cleaning Dorr thickener underflow has been under investigation in the mineral dressing laboratories of The Pennsylvania State University for some time. Results have been encouraging, and at least one plant installation has been made for this purpose and is now operating. The laboratory has also developed a gravity method of separation utilizing stream flow action, on a specially designed traveling belt machine. These two units, cyclones and gravity belt separators, have proved effective in removing sulfur from Dorr thickener underflows, so that it is possible to obtain a low sulfur product suitable for blending with other products of the preparation plant. This is particularly important to plants preparing coal for metallurgical purposes. **Ref.: (MINING ENGINEERING, February 1959) AIME Trans., 1959, vol. 214, p. 211.**

Subsurface Investigations of a Plant Site by *L. Scharon, et al.* (TP 4789L)—Before construction of an industrial plant on property of National Lead Company in Fredericktown, Missouri (Fig. 1), some 100 miles south of St. Louis, subsurface investigations were made of the proposed site. These investigations, consisting of electrical resistivity, seismic refraction, and churn drilling techniques, were confined to an area of 750 by 500 feet. The purposes of accumulating these data were to: (1) prepare an isopach map of the thickness of the overburden; (2) determine depth to bedrock at fixed points; and (3) determine soundness of the dolomite bedrock. **Ref.: (MINING ENGINEERING, February 1959) AIME Trans., 1959, vol. 214, p. 215.**

Sphalerite Flotation with Guanadine Compounds and Derivatives as Collectors by *Pierre R. Hines* (TN 462B)—Diphenyl guanidine gives a better recovery of the sphalerite and marmatite in the Bunker Hill ore, and with a higher grade concentrate than potassium ethyl xanthate. Further test work on other zinc ores is needed to determine fully what the characteristics of the guanidine-type collectors are and whether or not these collectors can be generally applied.

The diphenyl and dibutyl derivatives of both urea and guanidine are excellent flotation collectors. The relationship of diphenyl and dibutyl structures to their collecting properties has not been determined. **Ref.: (MINING ENGINEERING, February 1959) AIME Trans., 1959, vol. 214, p. 219.**

Quantitative Mineralogy as a Guide in Exploration by *R. J. P. Lyon and W. M. Tuddenham*— Studies made in various mining districts in the past have suffered from the basic inadequacy in the determination of the fine grained alteration minerals under the microscope. An integrated approach to quantitative mineralogy is described utilizing infrared absorption, X-ray diffraction, and differential thermal analysis. The application of these methods to the determination of the alteration of a small orthoclase phenocryst, the alteration envelopes surrounding veins in a piece of core, and the petrography of the standard G-1 granite sample are discussed. The application to areal sampling problems in a serpentine belt, to the mineralogy of a yearly mill feed composite; and as a guide to further drilling quantitative mineralogy in exploration. *AIME Annual Meeting, February 1959.* 59I77

SME Meeting Papers: *The following abstracts of papers presented at SME meetings are given for your information. Copies of these papers are available only if followed by a preprint order number. These preprints are obtained on a coupon basis. The coupon books may be purchased from SME headquarters for $5.00 a book (10 coupons) for members of AIME or $10.00 a book for nonmembers. Each coupon, properly filled out, entitles the purchaser to one preprint. Mail completed coupons to Preprints, Society of Mining Engineers, 29 W. 39th St., New York 18, N. Y.*

Glass Sand From the Ione Formation by *Woodrow W. Slade and Richard W. Heindel*—Owens-Illinois has placed in operation the first successful glass sand plant recovering a high silica sand from the Ione Formation. The Owens-Illinois plant began operations in March of 1955 and supplies a very low iron, low alumina silica sand to the glass and sodium silicate industries in the San Francisco and Bay Areas in California. The company's own Portland, Ore. glasshouse also buys from Ione.

Owens-Illinois' success at Ione did not come easy or cheap. The company inaugurated a campaign in 1950, exploring the over-all Ione formation in general. Final analysis indicated an area near Ione to be the most suitable from an economic standpoint. Gladding-McBean & Co. held the parent lease from the W. S. Howard Estate, and favorable negotiations followed with Gladding-McBean which paved the way for a $250,000 drilling and pilot plant study to prove the quality, processing, and acceptability of these sands.

At the termination of all drilling and pilot plant studies the board of directors of Owens-Illinois authorized the necessary funds to construct the existing facility at Ione. The over-all operation has been a huge success.

A series of slides will be shown in addition to the oral discussion. These slides will show some of the highlights of the Ione development.

The new Ione plant of Owens-Illinois will be discussed in general, and comments on mining and processing will be offered. *AIME Annual Meeting, February 1959.*

Consideration of Practical Ore Dressing Problems That Are Seemingly At Variance With the Theoretical by *Charles J. Veale*—The paper points out the necessity or importance of trying to get greater correlation between laboratory tests and actual plant results which are generally at variance with each other. It discusses test results to substantiate the belief that over-grinding of galena does not cause higher than normal lead losses in plant tailings. *AIME Annual Meeting, February 1959.* 59B67

Stockpiling Purposes, Methods, and Tools by *Laurance O. Millard*—The stockpiling of bulk materials is becoming increasingly important to our over-all economy. Large scale imports of ore, new processes, and plans for increased output have created numerous stockpiling problems and have resulted in interesting installations.

This paper will be devoted principally to the methods and tools of large scale storing and reclaiming as they are used in the broad field of stockpiling, which may include such specific purposes as surge, reserve storage, and blending. These tools range from earth-moving equipment, cranes, and bridges to belt conveyors equipped with trippers, stackers or tunnel feeding devices.

The selection of methods and tools is determined by the characteristics of the material to be stored and by its subsequent behavior in storage. Other important factors are the rate of storing and reclaiming, time in storage, climate, available space, and economics. Existing installations illustrate the effect of these factors and provide ideas for new projects. However, each problem requires careful study in order to assure the best performance. *AIME Annual Meeting, February 1959.* 59B59

Flocculation—Key to More Economical Liquid-Solids Separations by *Robert H. Oliver*—Proper use of flocculants can usually reduce the cost of liquid-solids separations. The cost of purchasing and applying flocculants and of operating and amortizing equipment are the major expenses involved. The most economical solution to a liquid-solids separation problem is that combination of flocculant and equipment costs which produces the lowest total annual expenditure.

This paper presents, in tabular form, all currently available information regarding properties of the many types of flocculants including composition, mechanisms of flocculation, fields of application, methods of preparation and addition, strengths of solution, ranges of pH effectiveness, commercial dosages and cost per pound. Thickening, clarification, and filtration testing methods are outlined for determining optimum type and dosage of flocculant. Three graphs are included to assist in conversion of laboratory test data to commercial flocculant dosages. *AIME Annual Meeting, February 1959.* 59B78

Physical Chemical Aspects of Flocculation by Polymers by *William F. Linke and Robert B. Booth*—The various methods for measuring the effectiveness of polymeric flocculants in the laboratory are described, and their interrelationships discussed. The mechanisms involved in floc formation and degradation have been deduced from chemical analysis of the various phases in flocculated systems. The amount of polymer which produces optimum flocculation of a colloid is an important measure of the type and extent of polymer to surface bonding. A number of examples are described.

The electrostatic interactions in a polymer-colloid system may be separated into those originating in the solution, on the solid surface, and on the polymer. The presence of salts in solution decreases the thickness of the ionic double layers about the particles and permits closer approach. Changes in pH or adsorbable-ion concentration will affect the surface charge, and may either aid or prevent flocculation. The presence of ionic groups along the polymer chain will make a polymer either more or less adsorbable on a colloidal surface. Systematic measurements were made on a number of systems in order to determine the relative importance of these variables.

The attachment of a polymer to a colloid may be by *hydrogen bonding*, by non-specific *double layer* interaction, or by specific *site-bonding*. These mechanisms are of different importance in different systems, and the choice of a flocculant for a given use must also take into account other factors, such as the molecular weight which can be obtained, and the amount of polymer which may be economically applied. *AIME Annual Meeting, February 1959.*

Blowing Ammonium Nitrate Through Small Diameter Drill Holes at the Utah Copper Mine of the Kennecott Copper Corp. by *Laurence E. Snow*—Experimentation aimed at taking advantage of cheaper commercial grade ammonium nitrate explosive led to the development of mobile powder blowing trucks at the Bingham Canyon Pit of the Kennecott Copper Corp. These trucks have brought about revolutionary changes in loading practices along with the following advantages: 1) A substantial yearly saving in powder costs. 2) A decrease in department blasting labor manhours per hole blasted. 3) A three-fold safety feature, including a) Less manhour exposure; b) Mechanical powder loading, being further removed from the bank, is of less hazardous nature; and c) Easier handling of a less sensitive powder. *AIME Annual Meeting, February 1959.*

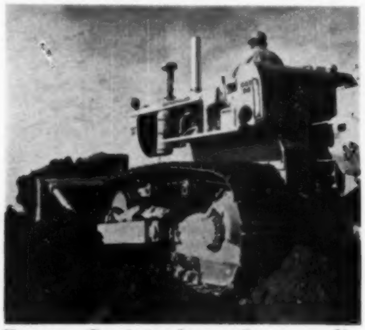
Current Trend of Production and Consumption of Sources of Energy by *Eugene Ayres*—The *Report to the President by the President's Materials Policy Commission*, issued in June 1952, made some long-term projections for electricity, coal, oil, gas, and hydropower which seemed reasonable from trends prior to 1947, but which do not seem reasonable from trends between 1947 and 1957. United States consumption of electricity, oil, and gas have exceeded the most optimistic predictions. On the other hand, consumption of coal and generation of electricity by hydropower have been lower than expected. Whether the proportion of coal in the total energy picture should begin to turn upward before 1965 or after 1975 will depend upon the actual size of U. S. reserves of oil and gas. *AIME Annual Meeting, February 1959.* 59K76.

MANUFACTURERS NEWS

NEWS / EQUIPMENT / CATALOGS

New Cat D8

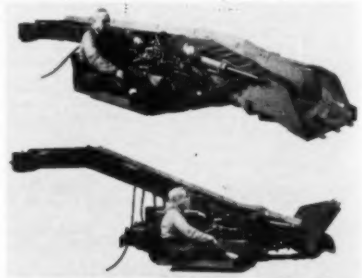
Increased weight, power, and productive ability gird the new Cat Series H D8 tractors for more profitable mining operation. *Caterpillar*



Tractor Co. introduces the new direct drive and torque converter units after a 3½ year development program. Double reduction final drive gearing helps provide ground clearance of nearly 20 in., greatest in this size class. Flywheel horsepower is up 18 pct, weight up over 4000 lb, and gage has been increased from 78 to 84 in. The new D8's are also 9 in. longer and 5 in. higher than the former models. **Circle No. 1.**

Low Height Shovel

A 28-in. high shovel loader has been designed for both metallic and



nonmetallic mining by *Myers-Whaley Co.* New machine is 16 ft overall and 54 in. wide. Crawler mounted and hydraulically operated, it has a crowding force of 4000 lb. Shovel action is oscillating and straight line conveyor raises to load into haulage vehicles. Shovel loader weighs about 6450 lb and is priced at about $12,000. **Circle No. 2.**

Induced Roll Separator

A high-intensity induced roll magnetic separator is offered by *Stearns Magnetic Products.* Inductively-magnetized rolls are arranged vertically, each revolving in a controlled magnetic circuit. Material is gravity fed. **Circle No. 3.**

Ion Exchange Resin

Dow Chemical Co. has announced a new ion exchange resin that demonstrates high selectivity for heavy metal cations. The first chelating resin to be made commercially available, the new Dowex Chelating Resin A-1 can be used in removing traces of heavy metals from a wide range of product streams, and in separating various heavy metals. **Circle No. 4.**

Nitro Carbo Nitrate Agent

Hercules Powder Co. has introduced a low cost, ready-to-use nitro carbo nitrate blasting agent called Dynatex. Mixing of blasting ingredients is eliminated and in many cases the agent will cost less per cu yd of blasted rock than a prilled ammonium nitrate-fuel oil mixture, claims Hercules. **Circle No. 5.**

Sinker Drill

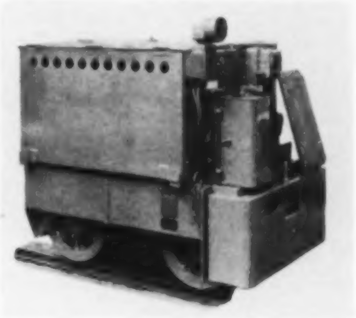
A new dry, dustless drill, the LHV45, by *Le Roi Div.*, Westinghouse Air Brake Co., is 25½ in. long and weighs 56 lb. Cuttings do not enter working parts but are drawn out the side of the chuck housing. LX-1 dust collector tank weighs 45 lb. The equipment is approved by the Bureau of Mines, approval number BM2531. **Circle No. 6.**

Small Cryderman Muckers

Shaft & Development Machines Inc. has introduced two small versions of the standard Cryderman shaft mucker. Both new units have been dubbed *Betsy*. One is designed to operate in circular shafts of 6 to 10 ft and in compartment shafts of 4x7 ft to 14x7 ft. The incline model (shown) runs on skids or rails. The units are operated by air cylinder controls and only one man is needed in the cage. **Circle No. 7.**

Compact Locomotive

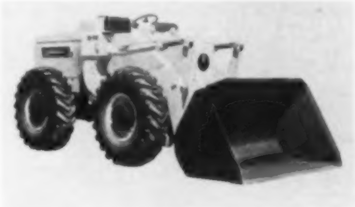
A new 3½-ton storage battery locomotive by *Atlas Car & Mfg. Co.* is designed with a telescoping cab that permits it to be hoisted on a cage only 5½x4 ft. Designated type Q, the locomotive permits use of almost double the capacity of the



average machine that can be easily caged for convenient transfer between levels. Unit can be supplied to fit on 5-ft cage also. Eight helical coil springs give good stability. **Circle No. 8.**

New Payloader

A new 4-wheel drive payloader, the H-90, has been announced by *Frank G. Hough Co.* as a replacement of the former HO model. Front



shroud is lower, for better visibility and safer operation. Load carry capacity is 9000 lb and buckets are available in sizes from 1½ to 5 cu yd. Both gas and diesel power models are available. **Circle No. 9.**

News & Notes

Conferences on the techniques of logging in uranium exploration have recently been held in Wyoming and New Mexico by *Century Geophysical Corp* . . . . *Matthiessen & Hegeler Zinc Co.* recently celebrated its 100th anniversary . . . . *Metals & Controls Corp.* has merged into *Texas Instruments Inc* . . . . Filtration engineering and development operations of *Dorr-Oliver Inc.* have been moved from Oakland, Calif., to the company's new international headquarters in Stamford, Conn.

NOTICE---SME PREPRINT AVAILABILITY

The following list of papers (from the 1959 San Francisco Annual Meeting) will be available until Jan. 1, 1960. Coupons received with the 1959 dues bills and those distributed at the 1959 Annual Meeting will also expire on this date. Purchased coupon books will be honored on any future date. A new listing of available papers will appear in a forthcoming issue. It will include additional papers presented at the 1959 Annual Meeting (San Francisco) and at other SME meetings throughout the year. Preprints may be obtained (upon presentation of properly filled out coupon) from SME Headquarters, 29 W. 39th St., New York 18, N. Y. Coupon books may be obtained from SME for $5 a book (10 coupons) for members or $10 a book for nonmembers. Each coupon entitles the purchaser to one preprint.

59H1—Water Law and Its Significance to the Mining Industry by Wells A. Hutchins.

59H2—Relation of Land Subsidence to Groundwater Withdrawals in the Upper Gulf Coast Region, Texas by Leonard A. Wood.

59F3—Hydraulic Mining of Gilsonite and Its Application to Coal Mining by J. H. Baker.

59H4—Recovery of Phosphates by In Situ Fluid Mining by Sylvain J. Pirson.

59F5—Coal Cleaning Plant Design for Minimum Operating Labor by Wm. M. Bertholf.

59F6—Coke Combustibility: A Neglected Characteristic by J. D. Price.

59B7—Union Carbide's Uranium Operation at Maybell, Colorado by K. W. Lentz.

59H8—A Rapid Method for Estimating Alumina in Feldspathic Sands by Hugh H. Bein.

59H9—Water Laws as Related to Dredging in Idaho by Robert A. Lothrop, Richard B. Porter, and Robert P. Porter.

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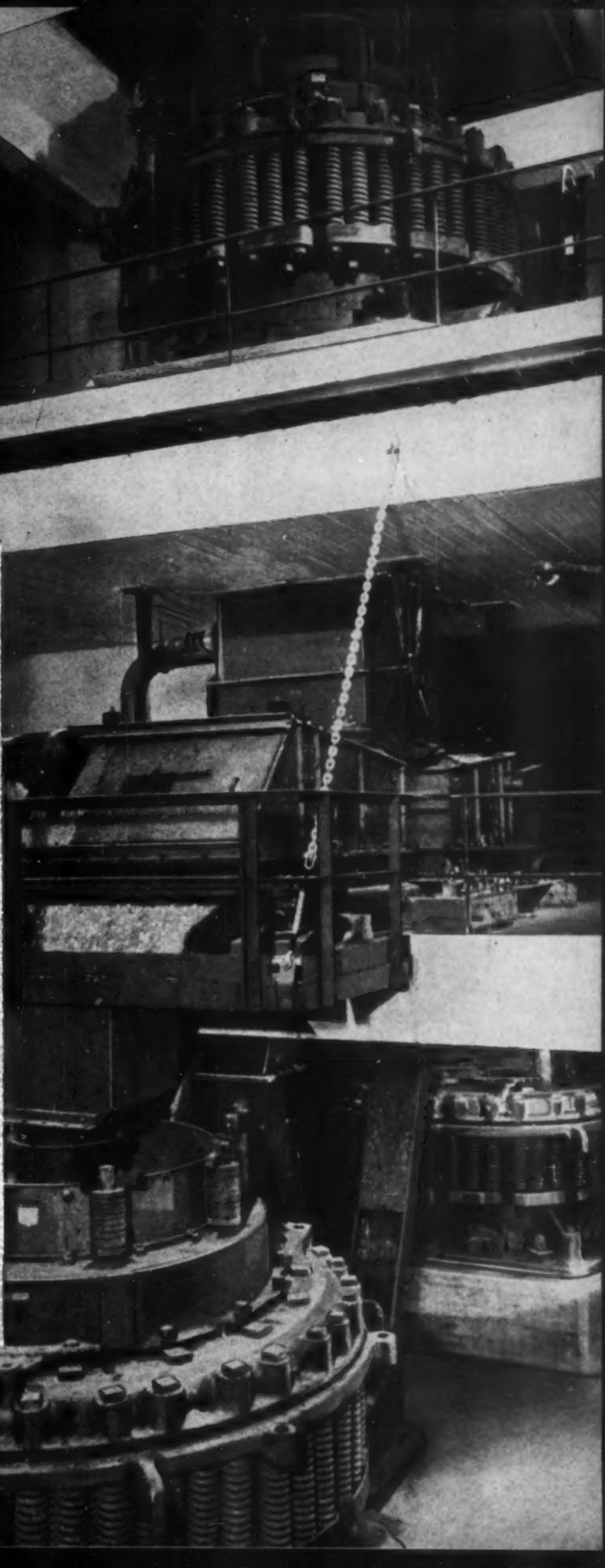

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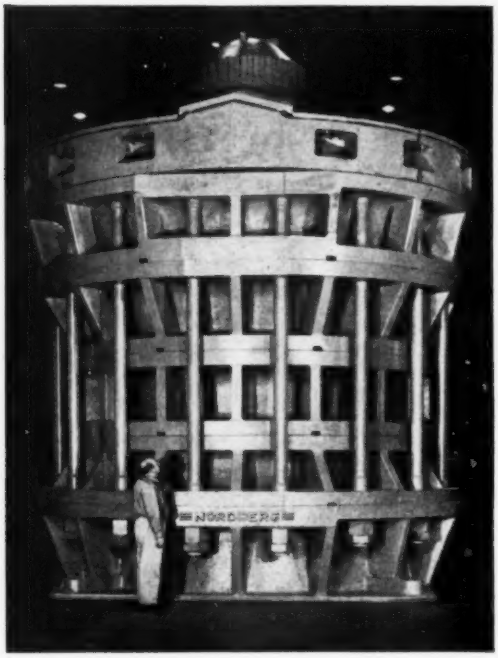

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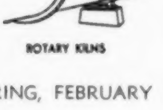

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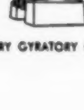

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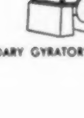

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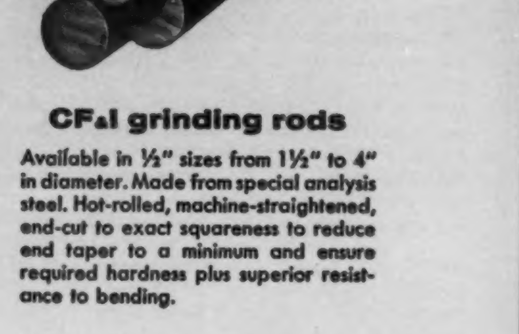

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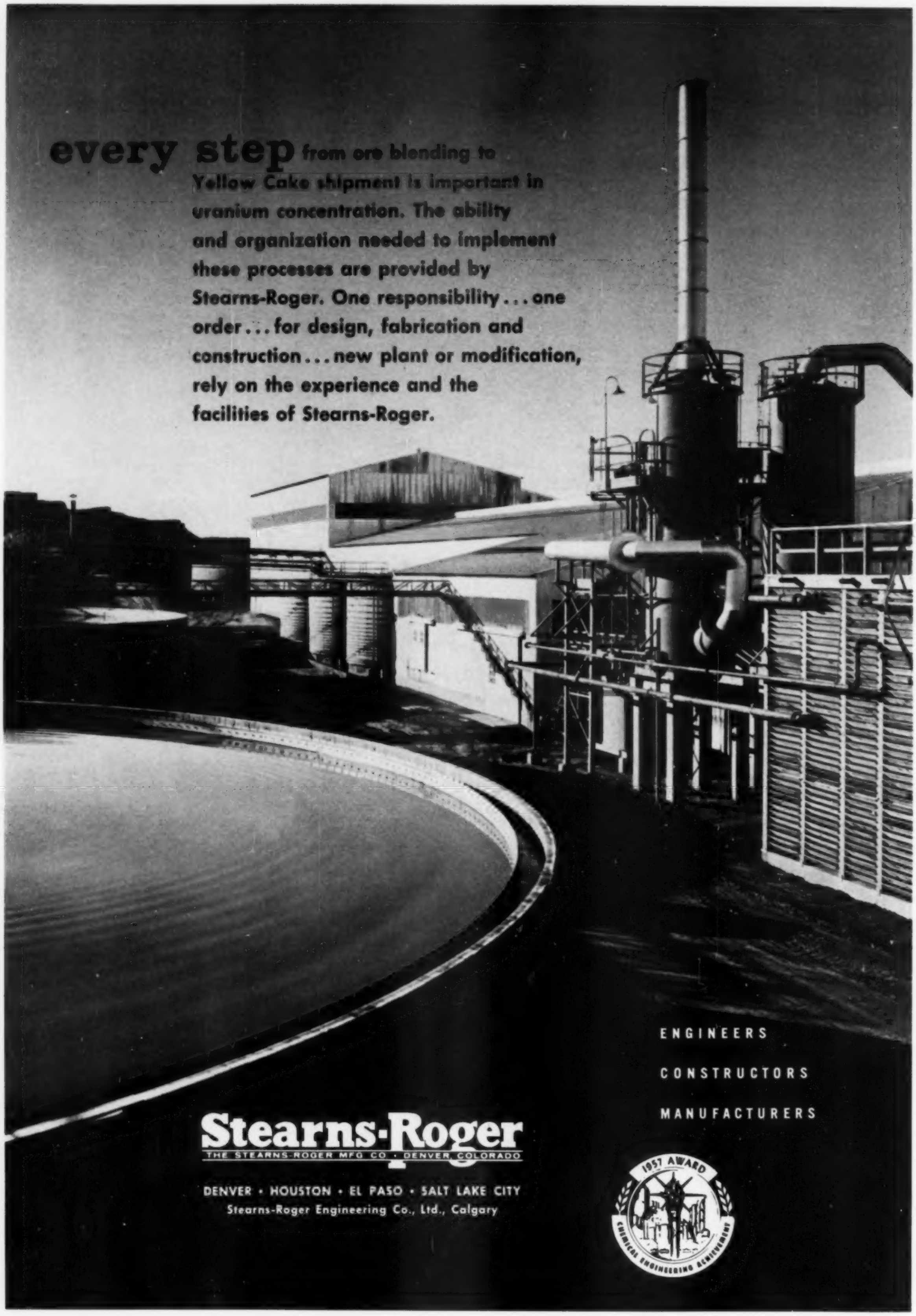

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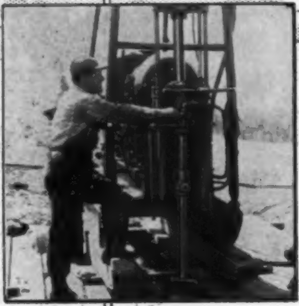

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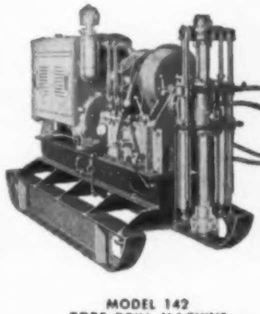

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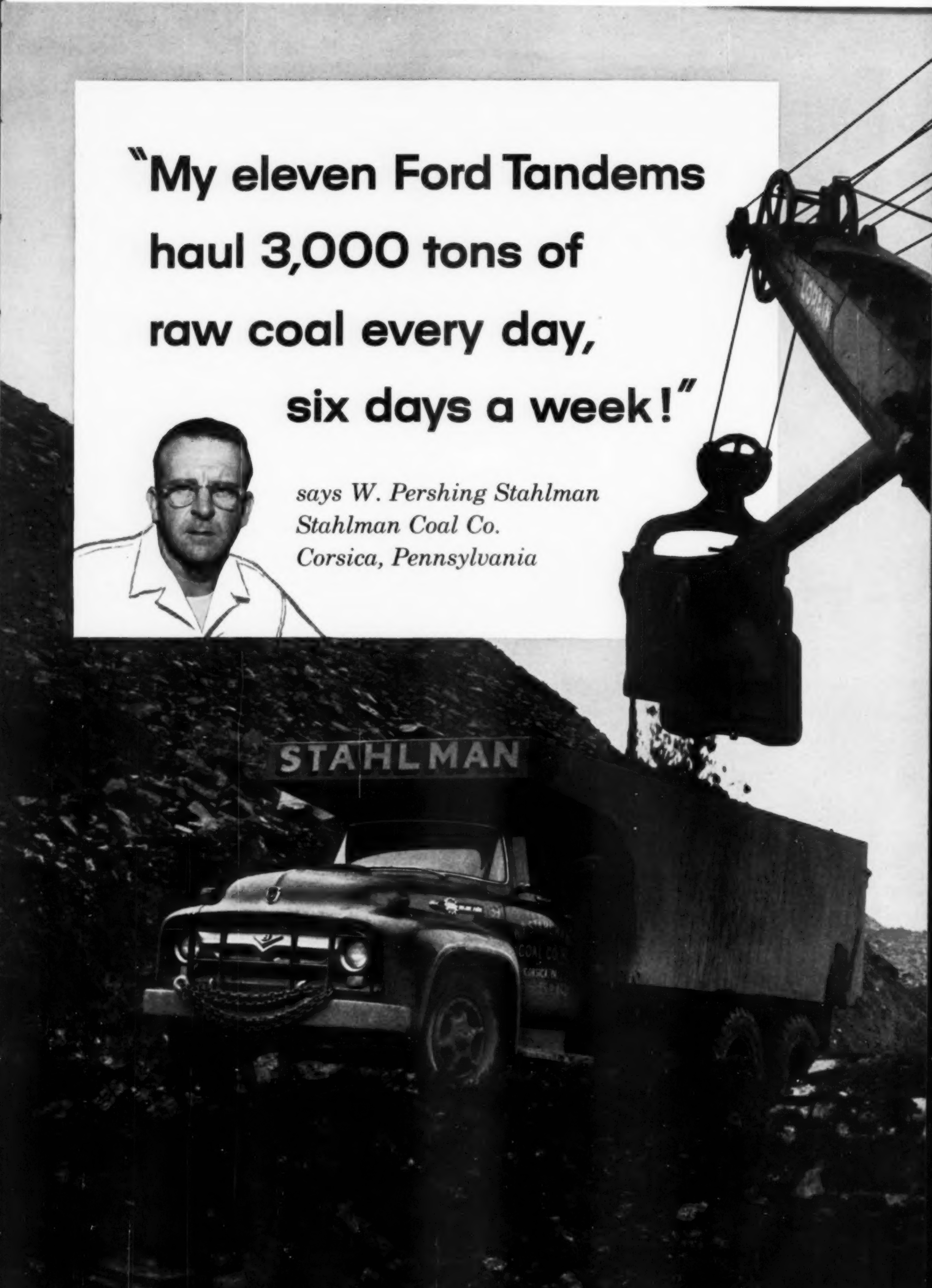
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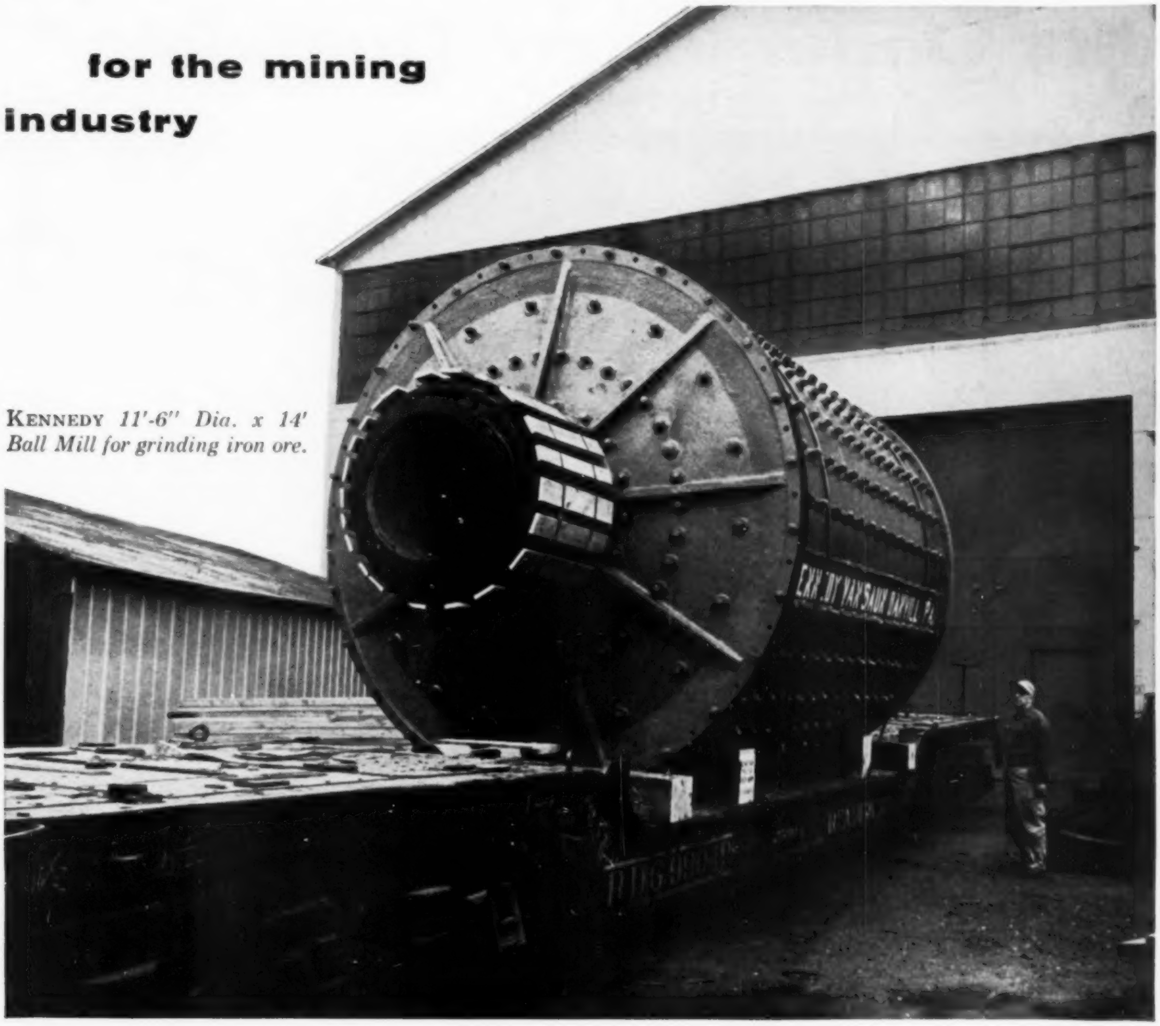

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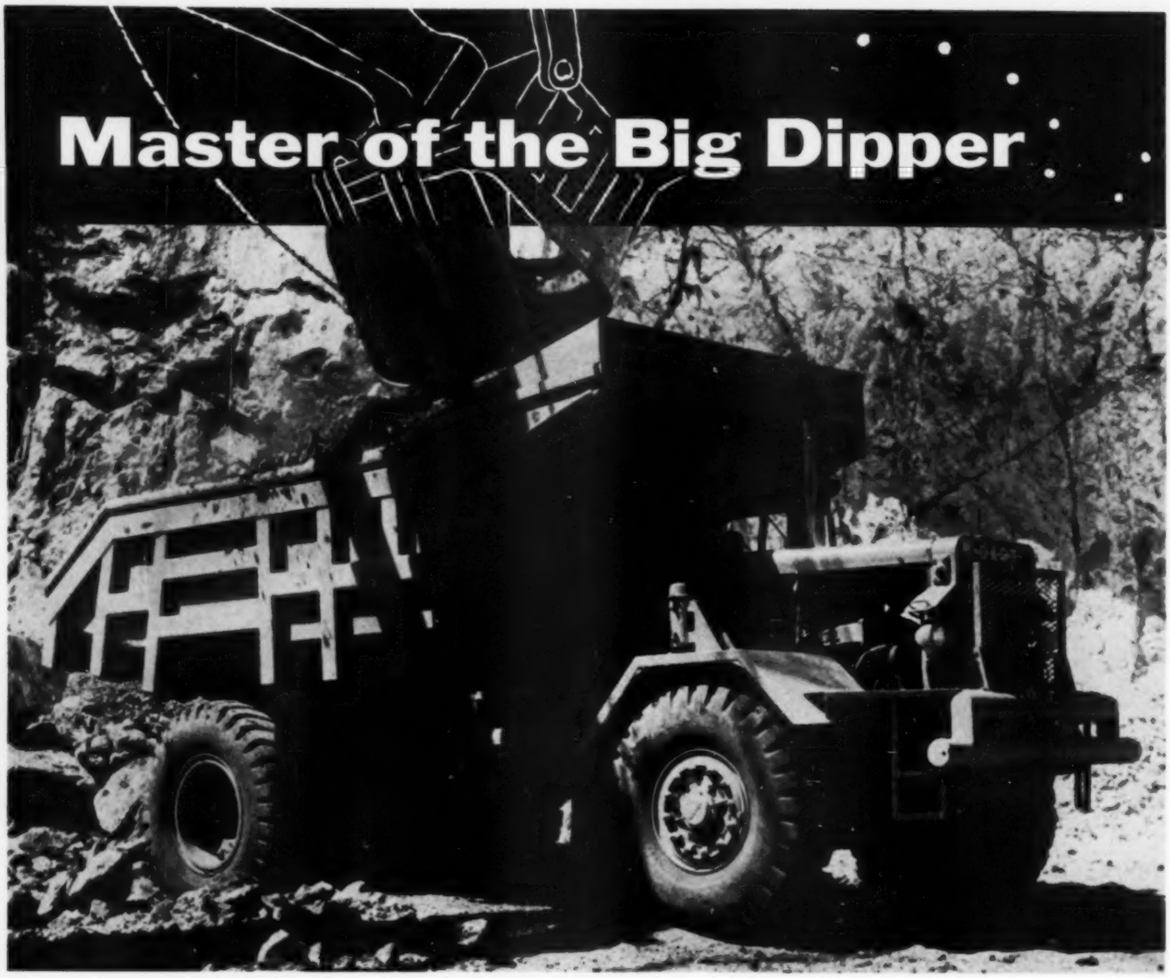

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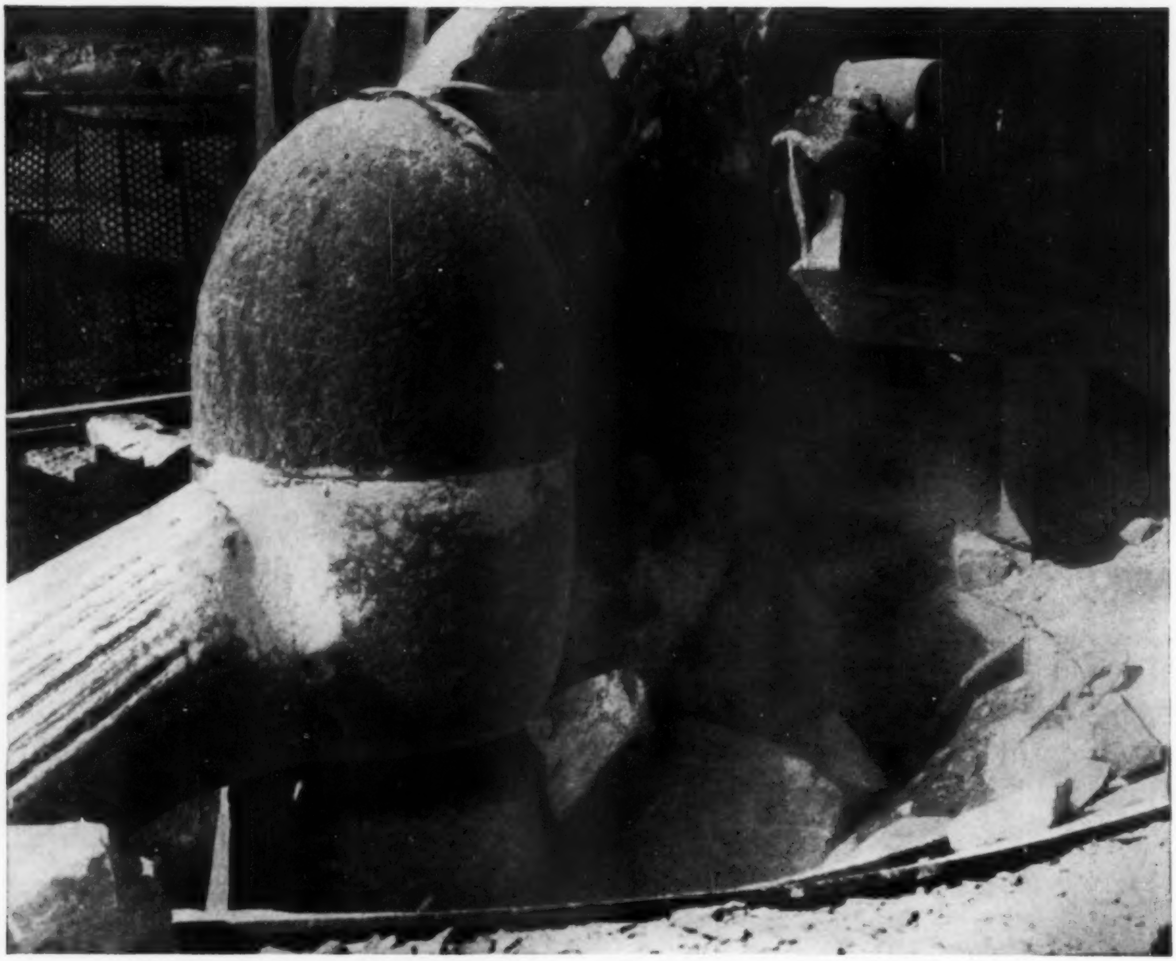

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Corporation Changes

National Gypsum Co. will acquire Huron Portland Cement Co., to "further diversify" its operations, through an exchange of shares . . . . Johns-Manville has entered the fiber glass industry by acquiring L.O.F. Glass Fibers Co. through its newly organized and wholly-owned subsidiary—Johns-Manville Fiber Glass Inc . . . . Canadian Javelin reportedly is to become a U. S. corporation with New York offices. New name: Javelin Corp. . . . Goldfield Consolidated Mines Co. expects to merge or consolidate with its 65-pct owned subsidiary, American Chrome Co. . . . Aluminum Co. of America plans to acquire electric cable maker Rome Cable Corp., fill out its facilities for making power transmission lines, including those of copper.

Domestic Iron Ore

Humboldt Mining Co. will step up ore pellet producing capacity by 640,000 tons a year by expanding its mining and concentrating facilities in Michigan's Upper Peninsula. Pellets will grade 60 pct and be suitable for direct blast furnace charging . . . . Jones & Laughlin's Lind-Greenway mine on the extreme west end of the Mesabi Range is under development. Work is to lead to output of about 700,000 gross tons of high grade beneficiated ore a year . . . . Anaconda Iron Ore (Ontario) Ltd. has drilled large reserves of low grade magnetite at its property near Nakina, Ont., but has no present plans for development. Ore is softer than taconites, can be upgraded readily to 65 pct Fe, and looks amenable to open pit operation.

Foreign Iron & Steel

Labrador's huge iron ore deposits have been brought a step closer to development with the announcement by Pickands Mather & Co. that initial contracts are being let for construction of a rail line into Wabush Lake. The 3½-sq mile Wabush Lake deposits are to be linked with the Quebec, North Shore & Labrador Ry. by the proposed 42-mile line at a point some 200 miles north of Seven Isles. Canadian Javelin owns the properties, which are being developed under lease by Wabush Iron Co., a firm owned jointly by Pickands Mather, Youngstown Sheet & Tube, Steel Co. of Canada, and Interlake Iron Corp. . . . In a recent double sale through private export-import firms, the USSR bought 20,000 tons of U. S. sheet steel for auto-making and the U. S. purchased 80,000 tons of Russian high grade metallurgical chrome ore. Last prior steel shipment to Russia was in 1956 . . . . Russians claim their iron ore output was up 5 pct last year. . . . Red China claims an estimated 100 billion tons of iron ore reserves, more than 600 deposits.

Iron Ore, Copper Subsidies Proposed

The Senate Interior Minerals Subcommittee is investigating proposed legislation that would permit the Secretary of Interior to buy copper on the open market and allow the Government to obligate the purchase of iron ore. Urged

by some producers, the plan was attacked by others. The proposal would meet strong opposition in the House, which turned down the minerals subsidy program last year.

Copper Notes

Kennecott Copper's Utah copper operation has become fully integrated with the addition of the Garfield smelter. The copper smelter, the world's largest, was bought from American Smelting & Refining last year and was taken over by Kennecott on January 2 . . . . Britain is selling the last of its stockpile copper—30,000 long tons—over a period of 10 months, at the rate of 2600 tons a month . . . . Export-Import Bank of Washington has authorized a supplementary credit of $15 million to Southern Peru Copper Corp. for the development of the Toquepala copper deposit. The money, an addition to an original credit of $100 million by the bank, will help meet inflated costs and finance certain changes in construction plans.

No Lead-Zinc Aid Program Planned

For the present the lead and zinc industry must rely on the Government's import quotas, notes Secretary of Interior Seaton. The Administration has made no plans for asking Congress for new aid-to-minerals legislation. The quotas are to be continued during the year.

Contest for British Aluminium Shares

Hoped-for bigger world markets form the basis for the recent struggle by two top American aluminum producers for partial control of British Aluminium Co. Ltd. Aluminum Co. of America had pitched itself against the joint effort of Reynolds Metals and a British firm, Tube Investments Group, in an attempt to purchase 4½ million outstanding shares of British Aluminium, authorized but as yet unissued. Success for the winner was to mean a larger share of the potentially huge foreign market, in which yearly per capita consumption amounts to 6.2 lb in Canada and Western Europe and averages a little more than half a pound in the rest of the world, as compared with 21 lb in the U. S. Alcoa's effort to gain effective control was welcomed by British Aluminium's management which was looking to finances for expansion. But Alcoa's offer of about $44 million was quickly followed by Reynolds which said it, with Tube Investment, would pay $98 million in stock and cash for all outstanding shares. A holding company plan would give Tube Investments a 51 pct ownership and Reynolds 49 pct. A late report indicates the Reynolds group has gained control of British Aluminium through acquisition of 80 pct of its shares, following an offer to purchase from individual shareholders.

Anaconda Girds for Aluminum Competition

A single firm, Anaconda Aluminum Co., with assets totaling more than $140 million, has been formed through the merger of three Anaconda Co. subsidiaries, Anaconda Aluminum Co., American Aluminum Co., and Cochran Foil Corp. The move is part of the parent firm's plan for "more vigorous participation" in the U. S. aluminum market. The newly expanded company is aiming at full integration as a producer of aluminum shapes and products.

THE BIG E ... SURPASSES EXPECTATIONS!

THE CASE OF THE DISAPPOINTED SALESMAN

Fred's a good salesman. Enthusiastic. Convinced of the proven superiority of the Eimco 105 Overhead Loader. But there are times when even a top salesman can't fight it. That was the case with Fred, when he wrote the following report to the home office:

"I have for many months been looking forward to getting another order for an Eimco 105 here*, but THIS ONE (Eimco 105 Overhead Loader) IS SO FAR AHEAD OF THEIR EXPECTATIONS AND THEIR PRODUCTION WITH THIS MACHINE IS SO NICELY HANDLED, THAT I DOUBT IF THERE WILL BE ANOTHER ORDER FORTHCOMING FOR QUITE A LONG WHILE."

"THEIR COSTS IN THIS MINING OPERATION ARE SO FAR BELOW THEIR CONSULTING ENGINEER'S ESTIMATES AND THEIR PRODUCTION HAS BEEN SO MUCH HIGHER THAN THEY EXPECTED, THAT THEY HAVE CURTAILED PLANS FOR EXPANDING THE DEVELOPMENT OF THIS PROPERTY."

What's a salesman to do? Fred had the answer. Make sure that other mining operators also learn about the savings potential, high production of the Eimco 105 Overhead Loader Crawler-Tractor. Fred, or one of his associates . . . the sales-engineers of The Eimco Corporation . . . will be glad to demonstrate the multiple advantages of the modern tractor . . . the rugged, reliable, maneuverable Eimco 105.

*—Original letter and name of mining company on file.

Just contact the sales office nearest you or The Eimco Corporation, P.O. Box 300 Salt Lake City 10, Utah, U.S.A. Tell 'em Fred suggested it!

EIMCO

THE EIMCO CORPORATION

SALT LAKE CITY, UTAH

EXPORT OFFICE, 51-52 SOUTH STREET, NEW YORK, N. Y.

BRANCHES AND DEALERS IN PRINCIPAL CITIES THROUGHOUT THE WORLD

B-379

TRYING TO TELL WHERE YOU ARE GOING BEFORE YOU GET THERE

A note of caution has been introduced into forecasts for the coming year by the SEC statistical series figures for capital expenditures. In brief, release No. 1571 predicts overall capital expenditure in the first quarter of this new year will slightly exceed that for the second half of 1958. Caution arises from the fact that the seasonally adjusted annual rate derived from this projects a 1959 just under the anticipated total for 1958.

Closer to home, nonferrous metals and motor vehicles had the sharpest decline between 1957 and 1958. And, the slight increase in outlays for the first quarter of 1959 is due primarily to the programs of building materials suppliers (including *industrial minerals*), *nonferrous metals*, and transportation equipment.

Too much importance can be given to these figures unless one remembers to differentiate between capital expenditures for *new* plant and equipment, and expenditures for replacement of capital equipment. We can recall at least a few managers, superintendents and foremen who were moaning to push the oldest half dozen trucks or drills over the dump a year ago. Given cash in the coffers, one should see considerable replacement activity, making up for lost time.

At least two sources are looking ahead with sales enthusiasm. Caterpillar has begun a steady flow of new products and new models that suggests a program to place a significant additional product on the market every month.

The head of another firm in the earthmoving field, one of the shrewdest men in the industry, told his competitors to stop crying and start building inventory, lest they find their customers back ordering within the next few months. And in December the Dept. of Commerce predicted a 15 to 20 pct increase in shipments of mining machinery in 1959 over 1958.

As late as last September business men were overestimating the rate of their own capital expenditures for the then current and coming quarters. Any validity of guesses as to where we are going in 1959 hinges on whether or not business is now underestimating their future expenditures.

WESTERN FIELD SECRETARY DIES

Roy E. O'Brien died in Salt Lake City January 9th. For almost a decade AIME's principal emissary in the West, Roy was active in every aspect of the Institute in "his" part of the country. His role in the history of AIME is excellently conveyed in the Appreciation by Past Presidents Andrew Fletcher and H. DeWitt Smith which appears on page 246.

MINING engineering TRENDS

Economic Outlook

The 1958 U. S. economy, starting deep in the recession carried over from 1957, began an upward climb after the April low and continued for a recovery almost as rapid as the collapse that preceded it. Reduced capital spending was one evidence of the downtrend and heavy slashes in inventories another. Both now are on the increase and the view of most economists is that the trend will continue, probably slowly as at present, but perhaps with much more vigor as the general business atmosphere clears.

In a survey of economic opinions by F. W. Dodge Corp., the 212 economists participating were almost uniformly enthusiastic about prospects for a better year in 1959. All but two expected the gross national product to rise above its mid-1958 level, and all but four thought industrial production would show a similar trend. The average forecast was for the G. N. P. to reach an annual rate of $460 billion by the fourth quarter, an upstep of about 4½ pct during the year.

But pitfalls and soft spots were seen also. The economists were especially leery of: 1) Inflation and runaway boom, with a counter-action sometime after 1959. 2) Possible cutting off of the recovery by excessive credit restrictions. 3) Prospects for a relatively slow decline in the number of unemployed. 4) A continuing profit squeeze facing many businesses. 5) Constantly rising wage rates. 6) Rising government deficits, high taxes, and restrictive tax structure.

Alltold, the outlook was to a stronger economy but not an untroubled one.

1958 U. S. Mineral Output

Domestic mineral production in 1958 fell below the levels of the year before. First estimates indicate a drop in dollar value of close to $1.8 billion. Preliminary total value for the year was put at $16.35 billion by the U. S. Bureau of Mines.

Metal values fell off considerably, partly due to lower average prices but also because of the sharp cuts in production that followed the price drops. Copper production sagged about 10 pct, lead and zinc about 23 pct, and iron ore output plummeted 36 pct from its 1957 total. But there were brighter areas. Uranium mines put out ore worth $36 million more than in 1957 and mercury producers tallied their eighth straight annual up-step in output.

A quick roundup using data from USBM preliminary reports, by commodity and mineral group, follows:

Aluminum—Primary aluminum production in 1958 was 1.56 million tons, a decrease of 5 pct from 1957 and 7 pct below the record high of 1956. The lower rate reflected a drop in demand created by the recession. However, markets began improving by midyear and at year's end production was at the same rate as at the end of 1957.

While there was reduced demand for aluminum in 1958, the industry had enlarged production capacity by December to more than 2.1 million annual tons, 300,000 tons more than at the start of the year. Two new producers, Ormet Corp. and Harvey Aluminum, started operations and Reynolds Metals Co. and the Kaiser Aluminum & Chemical Corp. each activated new potlines. New potlines, replacing obsolete facilities, were energized by the Aluminum Co. of America when it became the first industrial consumer of power from the St. Lawrence Seaway Project. Other facilities in various stages of construction will, upon completion, raise the U. S. annual primary aluminum capacity to 2.6 million tons.

The price for primary ingot was reduced 2¢ in April to 26.1¢ per lb. Effective August 1, the price was raised to 26.8¢.

Domestic output of bauxite in 1958 was about 1.36 million long dry tons, 4 pct below 1957. Production in the last half of 1958 was significantly greater than in the first half. Imports of bauxite, estimated at 7.7 million tons, marked an increase of 9 pct over 1957. Jamaica supplied 63 pct of the imports, Surinam, 30 pct, and British Guiana and Haiti combined, 7 pct. U. S. production represented about 15 pct of the new supply, compared with 17 pct in 1957.

Tariffs were suspended by Act of Congress until July 16, 1960, on crude bauxite, calcined bauxite, and alumina used for the production of aluminum. Alumina in significant quantities was imported for this use during the year.

Ormet Corp. became the fourth domestic alumina producer when it began operating its Burnside, La., plant. This plant, designed for an annual capacity of 350,000 tons of alumina, processes Surinam bauxite.

Coal—Bituminous coal and lignite production in 1958, estimated at 397 million tons by the Bureau of Mines, was down 19.4 pct from the 493 million tons produced in 1957 because of drops in domestic consumption and exports. The general outlook at the end of the year was for an improved coal market in 1959.

The average value of soft coal at the mine was estimated at $5 a ton, compared with $5.08 in 1957.

Pennsylvania anthracite production was 21 million tons, a 17-pct decrease from 1957 and the lowest in more than half a century. Continuation through 1958 of the general decline since World War II resulted from a 47-pct drop in anthracite exports coupled with a 10-pct decrease in apparent consumption in the U. S. Exports to Canada were off 16 pct and to all other destinations fell about 70 pct below 1957. The decline in consumption in the U. S. probably was caused by continued losses to competitive fuels and to a reduced rate of use by industrial consumers.

Copper—Mine production of copper in the U. S. in 1958 was almost 10 pct lower than that in 1957; refinery production from primary and secondary sources declined approximately 8 pct; and consumption dropped about 17 pct. Net imports of copper decreased nearly 24 pct while exports of refined copper were about the same as in 1957. Producers' stocks of refined copper dropped substantially in the last quarter of 1958, lowering the quantity in inventory at year's end about 20 pct below that of January 1, 1958.

The price of copper, which had reached a low of 25¢ per lb in January, advanced to 26½¢ in July and to 29¢ in October, where it remained through the end of the year. The Act suspending the U. S. import tax on copper expired on June 30, 1958, whereupon a duty of 1.7¢ per lb went into effect.

Throughout the first half of 1958 the copper industry was faced with the continuing problem of oversupply. However, the rise in demand created by improved industrial activity, coupled with curtailed output of the metal, due to work stoppages and voluntary cutbacks, resulted in more favorable conditions during the second half of the year. The domestic oversupply situation was tempered by Government acquisitions of copper under floor-price contracts.

Ferroalloys—Despite cutbacks in nickel production by most producers and a strike of workers at the Sudbury, Ont., mines and Port Colborne refinery of the International Nickel Co. of Canada Ltd., output was substantially greater than demand. Consequently, available stocks in North America in the hands of International Nickel and the U. S. Government on June 30 totaled 67,500 tons, exclusive of nickel in the national strategic stockpile. However, stocks held by consumers in the U. S. had declined from 23,300 tons at the beginning of 1958 to 12,000 tons on September 30. Domestic production of recoverable nickel increased about 3 pct to 11,000 tons in 1958.

Although Free World production of cobalt declined in 1958, output in the U. S. was about 21 pct greater than in 1957. Most of the cobalt metal produced in the U. S. was delivered to the Government.

Tungsten production continued the decline started in late 1956 after suspension of Government stockpile purchasing. In June 1958, the Hamme mine of Tungsten Mining Corp. in North Carolina and the Nevada-Massachusetts Co. operation in Nevada closed. During the last half of the year, byproduct output from the Climax Molybdenum Co. mine in Colorado and the Union Carbide Nuclear Co. mine in California comprised virtually all domestic production.

The Government's domestic car-lot manganese-purchase program for ore containing 40 pct or more manganese continued throughout 1958, but preliminary estimates are that ore production was somewhat lower than for 1957. Estimates of ore consumption and ore imports also were substantially lower than for 1957.

Molybdenum production, hampered by a strike at the Climax mine and by a cutback in operations at most byproduct plants, was the lowest in several years.

Termination of the domestic purchase program for chromite ore and concentrate in mid-1958 led to the closing of all chromite mines and mills in California, Oregon, and Alaska and to a sharp decrease in chromite production.

Gold & Silver—Domestic mine production of both gold and silver in 1958 reached the lowest point since 1946, again reflecting principally the lower output of base-metal ores yielding byproduct gold and silver. The 1958 output of gold was estimated at $60 million, a drop of about 5 pct from the $63 million of 1957. Output of silver was estimated at $30 million, about 14 pct lower than 1957's total of $34.5 million.

Industrial Minerals—The relatively high level of activity attained by the construction industry in 1958 sustained output of many mineral products.

Cement production in 1958 was about 7 pct higher than in 1957, but did not quite reach the record of 1956. Growing requirements for highways and other construction encouraged further expansion of cement-production capacity. By opening four new plants and adding to existing plants, the industry increased annual capacity to nearly 400 million bbl.

After a slow start, gypsum came back strongly late in the year and 1958 output exceeded 1957's.

The production of stone, sand, and gravel was slightly lower than in the previous year. Adverse weather early in 1958 hampered many construction projects. Other factors contributing to the decline were reduced activity in the steel, glass, and chemical industries.

Asbestos production in 1958 was slightly below 1957's. Asbestos output was supported in part by a Government purchase program which was completed at the end of the year.

A decrease in oil-well drilling in the U. S. had a depressing effect on the barite industry in 1958. Both domestic production and imports were well below 1957 levels.

Continued expansion of production facilities in 1958 resulted in an increase of about 16 pct in output of boron compounds. Certain of the compounds which have been developed recently have applications in the field of high-energy fuels for jet and rocket propulsion.

Fluorspar output in 1958 was lower than in 1957. Consumption requirements by steel, aluminum, and chemical industries were down and imports also were lower. Government purchase programs were in effect throughout the year.

Domestic production of sulfur declined in 1958. Output of recovered sulfur increased substantially, but this was more than offset by a drop in Frasch sulfur production. Imports from the newly developed sulfur mines in Mexico continue to increase; they now have become a major factor in the world market.

Salt requirements of industry were lower than in the previous year and production of salt consequently declined in 1958. Similarly, lime output was down about 15 pct.

Phosphate rock output and sales increased 5 pct in 1958 because of higher agricultural demand. Potash production remained about the same. U. S. companies continued to explore potash deposits in the Saskatchewan area of Canada.

Talc and feldspar production remained virtually unchanged in 1958 as building activity in the last half of the year increased substantially.

Output of clays was down about 10 pct because of decreased demand for refractories by the iron and steel industry. Kyanite production also declined about 10 pct.

Scrap mica production was about 10 pct less in 1958 than in 1957 because of lower industrial activity. A high level of production of muscovite block, film, and hand-cobbed mica was maintained under the Government domestic mica purchasing program.

Production of abrasive materials declined about 25 pct, largely because of reduced automobile and truck manufacture.

Iron Ore—Iron ore output was cut back as much as 50 pct in many of the nation's mining districts in the first part of 1958, and preliminary estimates indicate that by the year's end the totals for both tonnage and value were down 36 pct from 1957. The 1958 production is estimated at 66 million tons, compared with 104 million in 1957. Imports of iron ore were about 27 million tons, down more than 20 pct from 1957. Iron ore stocks were almost normal by the end of the year.

Steel demand increased sharply during the last four months of 1958. However, steel and pig iron production are estimated at 25 and 35 pct, respectively, below 1957's 112.7 million tons for steel and 78.4 million tons for pig iron. The steel mill operating rate for the last three months of 1958 was between 70 and 75 pct of capacity, compared with the year's low of 47.8 pct in April. Although estimated scrap consumption during 1958 was 27 pct lower than for the previous year, total scrap used made up 49.7 pct of the total charge (scrap plus pig iron), compared with 49.1 pct in 1957.

Lead & Zinc—Consumption of lead and zinc declined in 1958, reflecting a lower level of general industrial activity. A sharp decline in Government procurement further restricted demand. Decreases in domestic mine production were insufficient to offset continued large-scale imports and to prevent stock buildups.

An investigation by the Tariff Commission indicated the domestic mining industry was being damaged by imports and, as a result, the Commission recommended corrective action by the President. Congress considered but did not enact legislation recommended by the Department of the Interior to aid directly the domestic producers. An international conference, sponsored by the United Nations, explored methods whereby world surpluses of lead and zinc could be reduced.

To provide an appropriate and immediate remedy, import quotas, effective October 1, were allocated among exporting countries. The quotas were established at 80 pct of the average of U. S. imports in the period 1953 to 1957.

The imposition of import quotas and an upturn in consumption during the last quarter of the year were reflected in price rises in zinc from 10¢ per lb on October 1 to 11½¢ November 7. Lead rose from the year's low of 10¾¢ in August to 13¢ October 14. The year ended with a firmer tone to the market generated by decreasing stocks and larger sales volume.

Magnesium—Production of primary magnesium in 1958 was 30,400 tons, down 63 pct from 1957. Producers reported cutbacks due to accumulations in stocks. Shipment, which decreased 36 pct below 1957, increased during the fourth quarter of 1958.

In November 1958, Alabama Metallurgical Corp. began building a 7000-ton plant at Selma, Ala., to produce magnesium from dolomite. This installation is the first primary magnesium plant to be built with private funds since World War II.

Production of 6.5 million tons of magnesite and dolomite for basic refractories in 1958 represented an increase of 10 pct over 1957. H. K. Porter Co. Inc. completed construction of a new seawater magnesia and basic refractories plant at Pascagoula, Miss.

Mercury—Mercury production at domestic mines in 1958 reached 37,000 flasks, a 7-pct gain over 1957 and the largest since 1944. It marked the eighth consecutive annual increase.

Greater output of mercury in California, Nevada, and Idaho was only partially offset by declines in Alaska and Oregon. In the first 9 months of the year, industrial consumption fell 10 pct below the high average annual rate for the period 1955 to 1957. On the other hand, during that period 15,000 and 2200 flasks, respectively, of domestic and Mexican mercury were withdrawn from market through Government purchases under the General Services Administration guaranteed-price program. General imports were about a third of the 45,000-flask rate of 1957. Exports and re-exports again were only a small fraction of imports.

Mercury prices ranged from $220 to $230 a flask in January, and after strengthening to $237 to $243 in September, dropped back to about the January level as the year closed.

Titanium—Following a cutback in military requirements for titanium metal in mid-1957, production of titanium sponge dropped steadily to about 10 pct of the industry's capacity by mid-1958. Output began to increase during the third quarter of 1958 and total production for the year was about 4500 tons, or about a fourth the 1957 record of 17,000 tons.

Titanium sponge metal consumption for the year was about 3400 tons, less than half the 8200 tons used in 1957. The price of titanium sponge metal dropped during the year from $2.25 to $1.82 per lb for grade A-1 and from $2 to $1.70 per lb for grade A-2.

Because of the decrease in titanium metal production in 1958, consumption of rutile was well under the 1957 level. Production of titanium pigments was about 10 pct below the previous year. Consumption of ilmenite in 1958, mainly for pigments, was less than in 1957.

Domestic ilmenite production for 1958 decreased about 20 pct to 600,000 tons. Ilmenite imports in the first 8 months of 1958 were 264,000 tons and for the entire year are estimated to have been about 350,000 tons, 24 pct below 1957. Rutile output decreased about 12 pct to an estimated 9400 tons. Rutile imports decreased to 30 pct of the 1957 total to 26,000 tons.

The price range for ilmenite concentrate dropped during the year from $26.25 to $30 per long ton to $23 to $26 per long ton. The lower demand for rutile was reflected by a drop in price from 6 to 6¼¢ per lb at the beginning of 1958 to 4¾ to 5¢ per lb at the end of the year.

Uranium—Production of domestic uranium ore increased nearly 50 pct compared with 1957 and totaled about 5 million tons, valued at $114 million, f.o.b. mine. The 1957 value was $78 million.

Uranium concentrate production was at a rate of about 14,000 tons a year, compared with 10,000 tons in 1957 and 6000 tons in 1956. Producing states, in order of importance of uranium ore produced in 1958, were Utah, New Mexico, Colorado, Wyoming, Arizona, Washington, South Dakota, Alaska, California, Nevada, and Montana.

Twenty uranium mills, with a total capacity of 16,200 tpd of ore, were in production in the U. S. at the end of 1958, compared with 14 mills, with an aggregate capacity of 10,000 tons, in 1957. Most of the increase in milling capacity was in the Ambrosia Lake area, near Grants, N. M.

"Soviets . . . Worked Harder"

The American engineer can obtain up-to-date technical information as quickly and easily as his Russian counterpart, according to Ralph H. Phelps, director of the Engineering Societies Library of New York, one of the leading U. S. collections of technical literature.

Comparing the state-operated technical libraries of the USSR with the non-profit Engineering Societies Library, which operates without Government subsidy, Mr. Phelps said, "The Soviet centralized information services are not essentially better than the services available in this country."

Before a meeting of the American Society of Mechanical Engineers, Mr. Phelps commented, "If the Soviets have profited more than we have from the technical literature, one may believe that they have worked harder at using it. . . Some of the larger sections of the Soviet abstract services have no subject indexes and are therefore very difficult to use."

He declared that American technical literature can be and is being effectively used, and said, "None of the many abstracting and indexing services available in the Engineering Services Library is years behind, as was stated by a witness at a recent Senate committee hearing.

"The witness gave the impression that literature searches generally take a great amount of time (he mentioned 6 months as one example) and that searches cost from $1000 to $100,000 and even more. He also stated that 'the little man is out.' The Engineering Societies Library makes many literature searches each year for fees under $100 to under $1000. These are not complete literature searches and they may not deal with the largest and the most complex problems, but how often does *the little man* or anyone else deal with these?"

Mr. Phelps said that although there is no quick easy solution to difficulties imposed by the increasing flood of technical literature, indexing and searching services are far from choked by it. But he added that mechanical and electronic systems of storing information for quick access to large and diverse areas of information are apparently many years away.

"Efficient mechanized systems for large collections are not now available—not even at the very high prices charged for the large computers now being promoted for literature search work despite the fact that they were designed for other work and are not particularly efficient as literature searching tools."

The Engineering Societies Library includes a collection of 175,000 volumes, 20,000 maps, 5000 translations, and 10,000 bibliographies and indexes. The Library is generally considered the largest and most complete institution of its kind in the nation, if not in the world.

All publications received by the Library are made available to a cooperating organization, The Engineering Index, which publishes weekly and annual guides to technical literature. Last year the index provided annotated references to 27,000 articles.

The Library, now located at 29 West 39th St. in New York, is expected to move to the proposed United Engineering Center to be erected in the United Nations Plaza within the next two years.

Yearbooks On Stream

Writing under the guidance of Director Marling J. Ankeny, U. S. Bureau of Mines authors in the past year turned out a total of 12 volumes of Minerals Yearbooks, three volumes for 1957 and three for each of the years 1954, 1955, and 1956. And 12 volumes of their size and complexity are an enormous undertaking.

Of "Metal and Minerals—1957," the first volume of the set was off the press before the end of the year. It was the first since World War II days to be published during the year following the one covered. Upon issuance of Volumes II and III for 1957, the backlog that had accumulated because of the diversion of Bureau experts to other tasks during the World War and Korean emergencies will have been erased.

It is also great credit to the Bureau that the magnitude of the task of bringing the Yearbook up to date was increased by the broadening of coverage in recent years. Before the 1952 edition, the Yearbook was published each year as a single volume. The 1951 Yearbook, last of the single-volume series, contained 1694 pages, only slightly more than the number making up the 81 commodity and review chapters of the 1957 Volume I alone.

Single-volume Yearbooks of the past contained only a few chapters on individual states, and these were confined to only a few commodities. The new Yearbook for 1957, Volume III, will include chapters on production of *all* commodities in *every* state and territory, island possession, and trust territory.

Copies of the 1957 Minerals Yearbook, Volume I, Metals and Minerals (Except Fuels), can now be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at $3.50 a copy.

TRENDS IN REAL PRICES OF REPRESENTATIVE MINERAL COMMODITIES, 1890-1957

by CHARLES W. MERRILL

The price records of seven representative mineral commodities for the 68-year period 1890 through 1957 have been compiled and analyzed for significant trends. When these records are reduced to *real* prices in terms of dollars of constant purchasing power or to the purchasing power of industrial wages at average rates, a substantial overall fall in prices is revealed. This downtrend contradicts the widely held concept that heavy drafts on a mineral resource must lead to scarcity, reflected in rising prices.

Three metals (aluminum, copper, and pig iron), two fuels (bituminous coal and petroleum), and two nonmetals (sulfur and cement) have been chosen because of their pre-eminence in their respective categories, their significance in an industrial economy, and the ready availability of their price records. It might be added that these seven commodities were selected before any price figures were compiled; none was selected or rejected to substantiate any preconceived notions as to price trends. The overall importance of the seven is demonstrated by the fact that, taken together, they composed over three-fourths of the value of all minerals produced in the U. S. in 1957.

The first step in the analysis was to reduce the price records to a basis for significant comparisons. Two such comparisons have been made: 1) The quantities of each of the commodities that could have been purchased for an average hour's wage in each year, and 2) the unit price of each commodity through the years in terms of deflated dollars. These data are set forth in the accompanying table and two charts.

The quantities of the mineral commodity purchasable with the average wage for one hour's work in all manufacturing industries through 1926 were based on annual average prices and on average annual wage rates determined by Paul H. Douglas and published in his "Real Wages in the United States, 1890-1926." The series was extended through 1957 by the Bureau of Labor Statistics, U. S. Department of Labor.

Calculations based on these data show that the average worker could have purchased 1.28 lb of copper with his hourly wage in 1890, whereas his hourly wage would have purchased 8.11 lb in 1957, an increase of 633 pct in the 68-year period. An average hour's wage would have bought 10.85 gal of petroleum in 1890, compared with 33.04 gal in 1957. Even more spectacular is the increase in sulfur, of which 25.25 lb could have been purchased with the 1904 average hourly wage; 223.08 lb were purchasable with the wage in 1957—an increase of 883 pct. Comparable price data for sulfur are not available for years earlier than 1904. For every commodity, the calculations show an improvement in the wage earner's purchasing power in 1957 compared with the early years.

Measuring purchasing power in terms of wages does not give an entirely fair picture of the availability of a commodity in an economy. When the efficiency of an economy changes and the balance shifts among such elements as raw-material production, manufacturing, and service trade, the economic significance of an hour's work changes. Partly to meet such criticism, but mostly to present another interesting measure of the response of minerals to changing market conditions, a second set of calculations has been made to deflate unit prices for the seven commodities into terms of 1954 dollars. To accomplish this adjustment to a common 1954 parity, the Gross National Product Price Deflator, developed by the Office of Business Economics, U. S. Department of Commerce, was used. Although the results of these calculations are not as striking as those based on labor's increasing purchasing power, nevertheless the declines outweigh the rises in the prices of the mineral commodities. In terms of these deflated prices, aluminum and sulfur are much cheaper today than in the early years; copper was substantially cheaper in 1957 than in 1890; pig iron and petroleum are little changed; and only bituminous coal and cement have increased substantially. Strangely, the two mineral commodities with the strongest reserve positions are the two to exhibit rising real prices.

Now this apparent overall downtrend in prices has taken place during a period of almost fantastic increase in the demand for mineral products. The value of minerals consumed in the world during the period greatly exceeds all mineral consumption up to 1890. A stage has been reached in the U.S. in which 95 pct of the energy used is of mineral origin and in which machines, structures, roadways, communication facilities, and most other elements in the industrial economy are primarily of mineral origin. Even agricultural fertility is maintained, in large measure, by mineral fertilizers. A series published in Minerals Yearbook shows that the value of U. S. mineral products has risen from $615 million in 1890 to $18,000 million in 1957, a 29-fold increase. Even in deflated dollars, the increase has been eightfold, while population has expanded less than threefold.

Not only are demands of the industrial nations—the U. S., countries of Western Europe, and Japan—increasing at rapid rates, but those countries with agrarian economies are calling themselves underdeveloped and clamoring to industrialize. The ever-expanding mineral requirements in the U. S. and throughout the world show no abatement.

Mineral reserves frequently have been described as wasting assets. Much concern has been shown for future users, who have been pictured as finding themselves on a plundered planet. Conservationists have viewed the future with alarm and have demanded legislation and regulations to reduce the drain on mineral reserves.

C. W. MERRILL, Member AIME, is Chief, Division of Minerals, U. S. Bureau of Mines, Washington, D. C. **TP 4792K. Manuscript, Nov. 12, 1958. San Francisco Meeting, February 1959. AIME Trans., Vol. 214, 1959.**

It seems strange, then, that rapidly rising demand met from irreplaceable reserves should be accompanied by a downtrend in prices when measured in terms of average wages or even in deflated dollars. What factors have made this anomaly possible? There are many, but advancing technology and discovery are by far the most important.

It is interesting to note that industrialization, which has been made possible by minerals for machines, structures, and energy, has made a tremendous return to mineral exploitation through mechanization of mining, beneficiation, smelting, refining, and processing. In the early years of the period under discussion, hand drilling was common, and virtually all ore not drawn from chutes was hand-loaded. Hand tramming was as widespread as hand loading. Crushing and grinding were mechanized early, but the increase in efficiency since 1890 has been very great. Almost every phase of the processing of minerals has increased in efficiency through technologic advance. In fact, when a deposit or an ore was not amenable to major technologic advance, exploitation declined and in some instances stopped. For example, narrow veins containing free gold that would have been worked with profit in 1890 lie idle today, and the very large slate industry of 50 years ago survives only because artistic considerations cause a few architects to specify slate roofs on special jobs.

Technology's contributions to the mineral industry are not confined to mechanization, however. Many ores yielded only part of their content in the form of salable products when treated by the older metallurgical processes. Before selective flotation was developed, lead-zinc ores yielded only the lead and were penalized at the smelter for their zinc, whereas selective flotation yielded two or more marketable products. The percentage of valuable products recovered from other ores rose substantially. The higher recoveries and new coproducts and byproducts made it possible to work lower grade and less accessible orebodies. Frequently lowering the cutoff grade for ore added enormously to reserves.

Technology, science, and engineering also contributed to discovery through geology, geophysics, exploratory drilling, more reliable sampling, and many other ways. Discovery is of particular importance in petroleum and natural gas where new and improved exploration techniques have been major factors in maintaining reserves despite ever-increasing drains on known oil pools.

In addition to advancing technologies in discovery, extraction, and processing, technology in utilization also moves forward. Thus the growing demand for energy, which in 1890 was met largely by coal, has shifted progressively to petroleum and later to natural gas. Moreover, the efficiency of thermoelectric plants has risen, as evidenced by the fact that 7.05 lb of coal were burned to generate 1 kw-hr in 1890 compared with only 0.93 lb in 1957. Aluminum has assumed a larger role in transmitting electricity, relieving copper of some of the sharply rising demand. Looking to the future, there is strong evidence that the fissionable elements soon will carry part of the ever-rising burden that otherwise would have to be assumed by the fossil fuels.

This long record of downtrends in the prices of basic mineral raw materials is most encouraging to those looking into the future. Here is positive evidence to refute the alarmists who propose hoarding mineral resources in the name of conservation. Although wastefulness is not to be condoned, there is little to sustain the argument that use of minerals leads to an impoverished future. Those countries that have put their minerals to work have the high standards of living today and the bright futures.

The fact that the rapidly rising drafts on virtually all minerals in the 68-year period under review have been accompanied by falling prices, in terms of wages, has been a principal factor in the rising standard of living in countries industrialized during this period. With no sign that industrialization will slow, there is good reason to look toward a continuing rise in living standards.

Although there have been some painful consequences of a local nature, the general trends usually have been upward. Progress and change leave ghost towns and obsolete plants behind, but the replacements almost always are better and more efficient.

Exploration and technological research to maintain reserves and rising output cannot be taken for granted. A substantial part of the income from current production must be available to assure the future. Taxation must recognize the wasting nature of particular orebodies, and management must provide for future mineral supplies through exploration and technological research. Moreover, it is essential that such research take the bold approach that any rock formation may be transformed into ore through science, engineering, and new needs. The transformation of taconite from country rock to ore is an example of what certainly will be repeated many times in the future.

This presentation has been general. More detailed analysis of the data will show minor trends which have been obscured when averaged into the long-term trends. The effects of such factors as tariffs, quotas, subsidies, wartime regulations, discriminatory taxation and freight rates, and many other factors have been passed by. Some may think that they detect evidence that the downtrends in prices have been faltering in the last decade and will conclude that industrialization is about to outrun the mineral-supply base. However, it seems much too soon to reach any such conclusion. Major scientific and technologic discoveries have met many situations where stringencies were developing. The impending entry of nuclear energy into the power field could affect profoundly the trend lines for the fossil fuels.

It should be recognized that data like these permit many interpretations. Industrialists will justify accelerated industrialization; labor leaders will demand new pay increases; investors will insist on their share of the rising productivity. Moreover, by selecting segments of the series, special trends, each with its own interpretation, can be developed. The data are left with the reader.

In closing, the writer is convinced that the 68-year record of downtrends on the whole of the real prices of seven major mineral products gives a basis for forecasting a continued downtrend. Increasing attention is indicated to exploration for workable orebodies and to research in mineral processing and utilization. Today's submarginal deposits will provide the ore of tomorrow. Extraction efficiency will improve. The products of abundant resources will replace the products from reserves that are growing scarce. At the very least, we can look forward with confidence that the mineral industries with their allied engineers, technologists, and scientists will be able to provide the principal material basis for an expanding industrial economy at reasonable and probably lower real prices.

Table I. Market prices, quantities purchasable in te
representative mineral commoditie

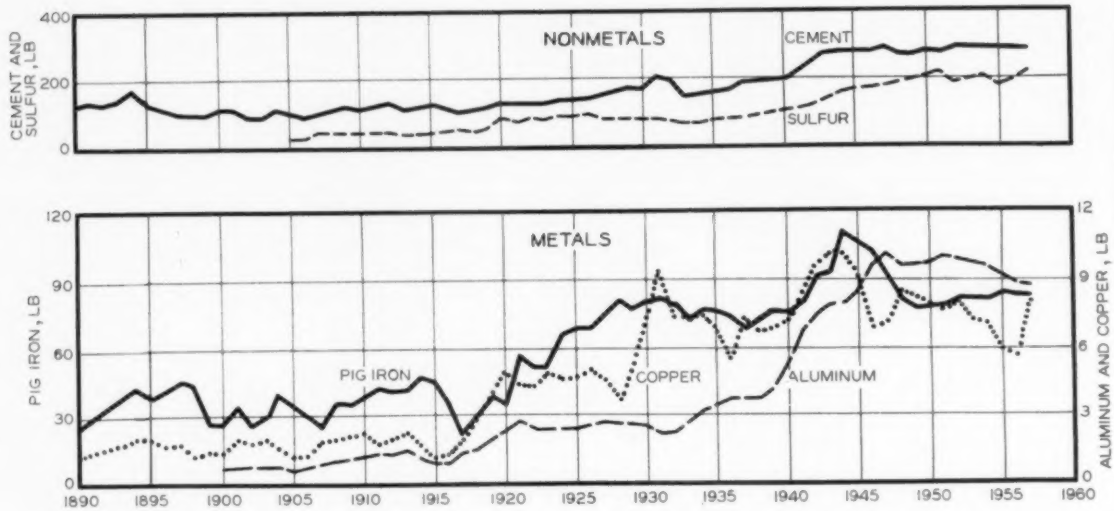
Year	Hourly Wage, $[1]	Gross National Product Deflator Reciprocal[2]	Prices: Metals: Aluminum, $ per Lb[3]	Prices: Metals: Copper, $ per Lb[4]	Prices: Metals: Pig Iron, $ per Long Ton[3]	Prices: Fuels: Bituminous Coal, $ per Ton[4]	Prices: Fuels: Petroleum, $ per 42-Gal Bbl[4]	Prices: Nonmetals: Sulfur, $ per Long Ton[4]	Prices: Nonmetals: Cement, $ per 376 Lb Bbl[4]	Quantity of Com: Aluminum, Lb	Quantity of Com: Copper, Lb
1890	0.199	3.416	[5]	0.1560	17.00	0.99	0.77	[5]	0.58	[5]	1.28
1891	0.202	3.465	[5]	0.1280	14.82	0.99	0.56	[5]	0.56	[5]	1.58
1892	0.203	3.601	[5]	0.1160	13.48	0.99	0.51	[5]	0.59	[5]	1.75
1893	0.205	3.526	[5]	0.1080	12.20	0.98	0.60	[5]	0.55	[5]	1.90
1894	0.200	3.770	[5]	0.0950	10.39	0.91	0.72	[5]	0.60	[5]	2.11
1895	0.200	3.818	[5]	0.1070	11.71	0.86	1.09	[5]	0.63	[5]	1.87
1896	0.205	3.918	[5]	0.1080	11.14	0.83	0.96	[5]	0.68	[5]	1.90
1897	0.203	3.906	[5]	0.1200	9.98	0.81	0.68	[5]	0.75	[5]	1.69
1898	0.204	3.794	[5]	0.1240	10.41	0.80	0.80	[5]	0.81	[5]	1.65
1899	0.209	3.667	[5]	0.1710	17.34	0.87	1.13	[5]	0.83	[5]	1.22
1900	0.216	3.506	0.330	0.1655	17.82	1.04	1.19	[5]	0.77	0.65	1.31
1901	0.219	3.526	0.330	0.1640	14.35	1.05	0.96	[5]	0.79	0.66	1.34
1902	0.227	3.416	0.330	0.1197	19.89	1.12	0.80	[5]	0.98	0.69	1.90
1903	0.236	3.377	0.330	0.1362	17.75	1.24	0.94	[5]	1.07	0.72	1.73
1904	0.236	3.340	0.330	0.1311	13.34	1.10	0.86	20.93	0.82	0.72	1.80
1905	0.239	3.258	0.332	0.1598	15.96	1.06	0.62	20.40	0.90	0.72	1.50
1906	0.248	3.180	0.394	0.1977	18.84	1.11	0.73	17.33	1.08	0.63	1.25
1907	0.257	3.059	0.379	0.2086	22.40	1.14	0.72	17.55	1.07	0.68	1.23
1908	0.250	3.082	0.293	0.1339	16.02	1.12	0.72	18.05	0.84	0.85	1.87
1909	0.252	2.982	0.240	0.1311	16.23	1.07	0.70	18.52	0.80	1.05	1.92
1910	0.260	2.896	0.220	0.1288	15.55	1.12	0.61	18.02	0.88	1.18	2.02
1911	0.263	2.910	0.204	0.1255	14.00	1.11	0.61	18.02	0.84	1.29	2.10
1912	0.274	2.801	0.205	0.1648	14.82	1.15	0.74	17.32	0.81	1.34	1.66
1913	0.285	2.788	0.214	0.1552	15.42	1.18	0.95	17.59	1.00	1.33	1.84
1914	0.287	2.756	0.194	0.1331	13.52	1.17	0.81	18.17	0.92	1.48	2.16
1915	0.287	2.670	0.246	0.1747	14.15	1.13	0.64	16.87	0.86	1.17	1.64
1916	0.320	2.370	0.355	0.2846	20.31	1.32	1.10	15.97	1.10	0.90	1.12
1917	0.364	1.921	0.378	0.2919	39.99	2.26	1.56	21.41	1.35	0.96	1.25
1918	0.448	1.649	0.329	0.2468	34.38	2.58	1.98	22.00	1.59	1.36	1.82
1919	0.529	1.609	0.330	0.1890	29.91	2.49	2.10	15.12	1.71	1.60	2.80
1920	0.663	1.414	0.333	0.1750	43.80	3.75	3.08	19.77	2.01	1.99	3.79
1921	0.607	1.658	0.263	0.1265	24.05	2.89	1.73	17.81	1.89	2.31	4.80
1922	0.574	1.755	0.209	0.1356	25.00	3.02	1.61	16.37	1.76	2.74	4.23
1923	0.620	1.708	0.260	0.1461	27.15	2.68	1.34	16.06	1.89	2.38	4.24
1924	0.636	1.728	0.278	0.1316	21.87	2.20	1.43	16.26	1.80	2.29	4.83
1925	0.645	1.698	0.282	0.1416	21.32	2.04	1.68	15.61	1.77	2.29	4.56
1926	0.647	1.691	0.275	0.1393	21.06	2.06	1.88	18.00	1.71	2.35	4.64
1927	0.647	1.733	0.258	0.1305	19.35	1.99	1.30	18.00	1.62	2.51	4.96
1928	0.662	1.720	0.243	0.1468	18.32	1.86	1.17	18.00	1.57	2.72	4.51
1929	0.662	1.713	0.243	0.1823	19.15	1.78	1.27	18.00	1.48	2.72	3.63
1930	0.647	1.779	0.238	0.1311	18.18	1.70	1.19	18.00	1.44	2.72	4.94
1931	0.602	1.988	0.233	0.0824	16.45	1.54	0.65	18.00	1.11	2.58	7.31
1932	0.528	2.208	0.233	0.0567	14.99	1.31	0.87	18.00	1.02	2.26	9.31
1933	0.521	2.220	0.233	0.0715	16.30	1.34	0.67	18.00	1.33	2.24	7.29
1934	0.625	2.092	0.222	0.0853	18.64	1.75	1.00	18.00	1.54	2.82	7.33
1935	0.647	2.115	0.195	0.0876	19.12	1.77	0.97	18.00	1.51	3.32	7.39
1936	0.654	2.064	0.190	0.0958	20.00	1.76	1.09	18.00	1.51	3.44	6.83
1937	0.736	2.025	0.198	0.1327	23.60	1.94	1.18	18.00	1.48	3.72	5.55
1938	0.736	2.053	0.200	0.1010	22.35	1.95	1.13	17.00	1.45	3.68	7.29
1939	0.743	2.071	0.200	0.1107	21.75	1.84	1.02	16.00	1.47	3.72	6.71
1940	0.773	2.046	0.188	0.1140	23.15	1.91	1.02	16.00	1.46	4.11	6.78
1941	0.855	1.881	0.165	0.1187	24.10	2.19	1.14	16.00	1.47	5.18	7.20
1942	1.004	1.684	0.150	0.1187	24.19	2.36	1.19	16.00	1.53	6.69	8.46
1943	1.130	1.551	0.150	0.1187	24.19	2.69	1.20	16.00	1.56	7.53	9.52
1944	1.197	1.522	0.150	0.1187	24.17	2.92	1.21	16.00	1.59	7.98	10.08
1945	1.204	1.477	0.150	0.1187	25.19	3.06	1.22	16.00	1.63	8.03	10.14
1946	1.278	1.340	0.150	0.1392	27.84	3.44	1.41	16.00	1.72	8.52	9.18
1947	1.449	1.119	0.150	0.2115	34.86	4.16	1.93	17.00	1.90	9.66	6.85
1948	1.583	1.136	0.155	0.2220	43.38	4.99	2.60	18.00	2.18	10.21	7.13
1949	1.642	1.125	0.170	0.1936	46.98	4.88	2.54	18.00	2.30	9.66	8.48
1950	1.716	1.113	0.176	0.2146	48.24	4.84	2.51	18.00	2.35	9.75	8.00
1951	1.865	1.034	0.190	0.2437	53.62	4.92	2.53	22.00	2.55	9.82	7.65
1952	1.962	1.025	0.194	0.2437	54.84	4.90	2.53	22.50	2.54	10.11	8.05
1953	2.081	1.008	0.209	0.2892	57.00	4.92	2.68	22.50	2.68	9.96	7.20
1954	2.126	1.000	0.218	0.2982	57.61	4.51	2.78	26.50	2.78	9.75	7.13
1955	2.208	0.989	0.237	0.3739	58.77	4.50	2.77	26.50	2.89	9.32	5.91
1956	2.327	0.960	0.260	0.4188	62.22	4.82	2.79	26.50	3.08	8.95	5.56
1957	2.431	0.945	0.275	0.2999	65.40	5.08	3.09	24.41	3.21	8.84	8.11

[1] The average hourly earnings series is that developed for all manufacturing industries by Paul H. Douglas and published in his *Real Wages in th* Labor. [2] The Gross National Product Implicit Price Deflator Reciprocals are based on the series developed by the Office of Business Economics, U.S *ruary 1957*, p. 7 for 1954-56 reciprocals, and *Economic Report of the President, January 1958*, p. 122 for 1957 reciprocal; the 1890-1928 reciprocals a Bureau of Mines. [5] Data not available.

erms of average hourly wages, and deflated prices for
ies in the United States, 1890-1957

Commodity Purchasable for Wage of One Hour of Labor						Adjusted Price (In 1954 Dollars)						
per, b	Pig Iron, Lb	Bituminous Coal, Lb	Petroleum, Gal	Sulfur, Lb	Cement, Lb	Aluminum, $ per Lb	Copper, $ per Lb	Pig Iron, $ per Lb	Bituminous Coal, $ per Lb	Petroleum, $ per 42-Gal Bbl	Sulfur, $ per Long Ton	Cement, $ per 376-Lb Bbl
28	26.22	402	10.85	[5]	129	[5]	0.533	58.07	3.38	2.63	[5]	1.98
58	30.53	408	15.15	[5]	136	[5]	0.444	51.35	3.43	1.94	[5]	1.94
75	33.73	410	16.72	[5]	129	[5]	0.418	48.54	3.56	1.84	[5]	2.12
90	37.64	427	14.35	[5]	140	[5]	0.381	43.02	3.38	2.12	[5]	1.94
11	43.12	440	11.67	[5]	125	[5]	0.358	39.17	3.43	2.71	[5]	2.26
87	38.26	465	7.71	[5]	119	[5]	0.409	44.71	3.28	4.16	[5]	2.41
90	41.22	494	8.97	[5]	113	[5]	0.423	43.65	3.25	3.76	[5]	2.66
69	45.56	501	12.54	[5]	102	[5]	0.469	38.98	3.16	2.66	[5]	2.93
65	43.90	510	10.71	[5]	95	[5]	0.470	39.50	3.04	3.04	[5]	3.07
22	27.00	480	7.77	[5]	95	[5]	0.627	63.50	3.19	4.14	[5]	3.04
31	27.15	415	7.62	[5]	105	1.157	0.580	62.48	3.65	4.17	[5]	2.70
34	34.19	417	9.58	[5]	104	1.164	0.578	50.60	3.70	3.38	[5]	2.79
90	25.56	405	11.92	[5]	87	1.127	0.409	67.94	3.83	2.73	[5]	3.35
73	29.78	381	10.54	[5]	83	1.114	0.460	59.94	4.19	3.17	[5]	3.61
80	39.63	429	11.53	25.25	108	1.102	0.438	44.56	3.67	2.87	69.91	2.74
50	33.54	451	16.19	26.24	100	1.082	0.520	52.00	3.45	2.02	66.46	2.93
25	29.49	447	14.27	32.06	86	1.253	0.629	59.91	3.53	2.32	55.11	3.43
23	25.60	451	14.99	32.80	90	1.159	0.638	68.80	3.49	2.20	53.68	3.27
87	35.00	446	14.58	31.02	112	0.903	0.413	49.37	3.45	2.22	55.63	2.59
92	34.78	471	15.12	30.48	118	0.716	0.391	48.40	3.19	2.09	53.23	2.39
.02	37.45	464	17.90	32.32	111	0.637	0.373	45.03	3.24	1.77	52.19	2.55
.10	42.08	474	18.11	32.69	118	0.594	0.365	40.74	3.23	1.78	52.44	2.44
.66	41.41	477	15.55	35.44	127	0.574	0.462	41.51	3.22	2.07	48.51	2.27
.84	41.40	483	12.60	36.29	107	0.597	0.433	42.90	3.29	2.65	49.04	2.79
.16	47.55	491	14.88	35.38	117	0.535	0.367	37.26	3.22	2.23	50.08	2.54
.64	45.43	508	18.83	38.11	125	0.657	0.466	37.78	3.02	1.71	45.04	2.30
.12	35.29	485	12.22	44.88	109	0.841	0.675	48.13	3.13	2.61	37.85	2.61
.25	20.39	322	9.80	38.08	101	0.726	0.561	76.82	4.34	3.00	41.13	2.59
.82	29.19	347	9.50	45.61	106	0.543	0.407	56.69	4.25	3.27	36.28	2.62
.80	39.62	425	10.58	78.37	116	0.531	0.304	48.13	4.01	3.38	24.33	2.75
.79	33.91	354	9.04	75.12	124	0.471	0.247	61.93	5.30	4.36	27.95	2.84
.80	56.54	420	14.74	76.34	121	0.436	0.210	39.87	4.79	2.87	29.53	3.13
.23	51.43	380	14.97	78.54	123	0.367	0.240	43.88	5.30	2.83	28.73	3.09
.24	51.15	463	19.43	86.48	123	0.444	0.250	46.37	4.58	2.29	27.43	3.23
.83	65.14	578	18.68	87.62	133	0.480	0.227	37.79	3.80	2.47	28.10	3.11
.56	67.77	632	16.13	92.55	137	0.479	0.240	36.20	3.46	2.85	26.51	3.01
.64	68.81	628	14.45	80.52	142	0.465	0.236	35.61	3.48	3.18	30.44	2.89
.96	74.90	650	20.90	80.52	150	0.447	0.226	33.53	3.45	2.25	31.19	2.81
.51	80.94	712	23.76	82.38	159	0.418	0.252	31.51	3.20	2.01	30.96	2.70
3.63	77.43	744	21.89	82.38	168	0.416	0.312	32.80	3.05	2.18	30.83	2.54
4.94	79.72	761	22.84	80.52	160	0.423	0.233	32.34	3.02	2.12	32.02	2.56
7.31	81.97	782	38.90	74.92	204	0.463	0.164	32.70	3.06	1.29	35.78	2.21
9.31	78.90	806	25.50	65.71	195	0.514	0.125	33.10	2.89	1.02	39.74	2.23
7.29	71.60	778	32.66	64.84	147	0.517	0.159	36.19	2.97	1.49	39.96	2.95
7.33	75.11	714	26.25	77.78	153	0.464	0.178	38.99	3.66	2.09	37.66	3.22
7.30	75.80	731	28.01	80.52	161	0.412	0.185	40.44	3.74	2.05	38.07	3.19
6.83	73.25	743	25.20	81.39	163	0.392	0.198	41.28	3.63	2.25	37.15	3.12
5.55	69.86	759	26.20	91.59	187	0.401	0.269	47.79	3.93	2.39	36.45	3.00
7.29	73.76	755	27.36	96.98	191	0.411	0.207	45.88	4.00	2.32	34.90	2.98
6.71	76.52	808	30.59	104.02	190	0.414	0.229	45.04	3.81	2.11	33.14	3.04
6.78	74.80	809	31.83	108.22	199	0.385	0.233	47.36	3.91	2.09	32.74	2.99
7.20	79.47	781	31.50	119.70	219	0.310	0.223	45.33	4.12	2.14	30.10	2.77
8.46	92.97	851	35.44	140.56	247	0.253	0.200	40.74	3.97	2.00	26.94	2.58
9.52	104.64	840	39.55	158.20	272	0.233	0.184	37.52	4.17	1.86	24.82	2.44
0.08	110.93	820	41.55	167.58	283	0.228	0.181	36.79	4.44	1.84	24.35	2.42
0.14	107.06	787	41.45	168.56	278	0.222	0.175	37.21	4.52	1.80	23.63	2.41
9.18	102.83	743	38.07	178.92	279	0.201	0.187	37.31	4.61	1.89	21.44	2.30
6.85	93.11	697	31.53	190.93	287	0.168	0.237	39.01	4.66	2.16	19.02	2.13
7.13	81.74	634	25.57	196.99	273	0.176	0.252	49.28	5.67	2.95	20.45	2.48
8.48	78.29	673	27.15	204.34	268	0.191	0.218	52.85	5.49	2.86	20.25	2.59
8.00	79.68	709	28.71	213.55	275	0.196	0.239	53.69	5.39	2.79	20.03	2.62
7.65	77.91	758	30.96	189.89	275	0.196	0.252	55.44	5.09	2.62	22.75	2.63
8.05	80.14	801	32.57	195.33	290	0.199	0.250	56.21	5.02	2.59	23.06	2.60
7.20	81.78	846	32.61	207.18	292	0.211	0.292	57.46	4.96	2.70	22.68	2.70
7.13	82.66	943	32.12	179.71	288	0.218	0.298	57.61	4.51	2.78	26.50	2.78
5.91	84.16	982	33.48	186.64	287	0.234	0.370	58.12	4.45	2.74	26.21	2.86
5.56	83.78	966	35.03	196.70	284	0.250	0.402	59.73	4.63	2.68	25.44	2.96
8.11	83.26	957	33.04	223.08	285	0.260	0.283	61.80	4.80	2.92	23.07	3.03

ges in the United States, 1890-1926, Houghton Mifflin Co., New York, 1930, and extended 1927-57 by the U.S. Bureau of Labor Statistics, Department of
omics, U.S. Dept. of Commerce and published in *National Income—1954 Edition*, pp. 216-17 for 1929-1953 reciprocals, in *Survey of Current Business*, Feb-
eciprocals are based on unpublished work sheets of John Kendrick. [3] *Metal Statistics* series, *American Metal Market*. [4] *Minerals Yearbook* series, U.S.



Figs. 1 and 2–Quantities of selected mineral commodities pur
earnings series used is the one developed for all manufactur
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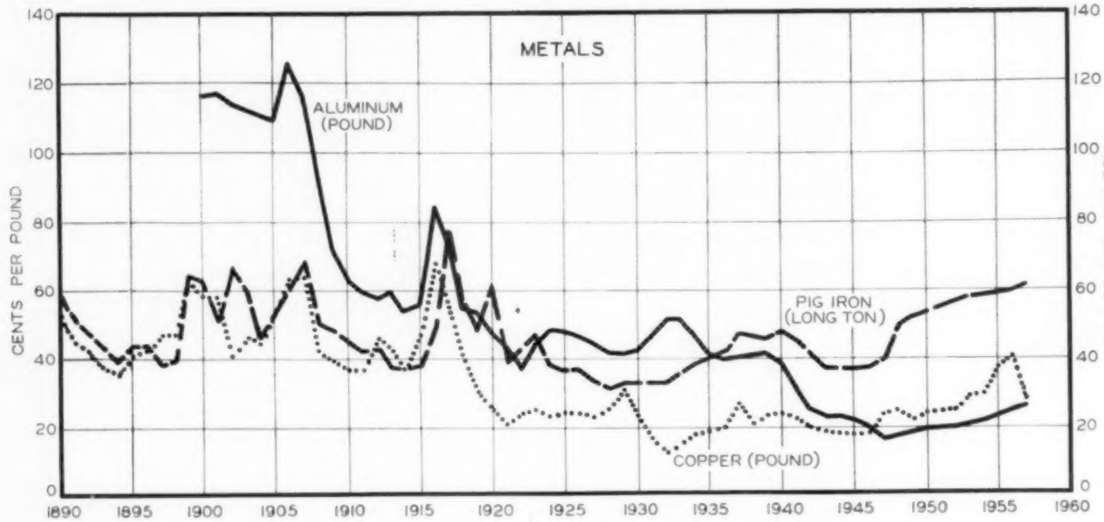
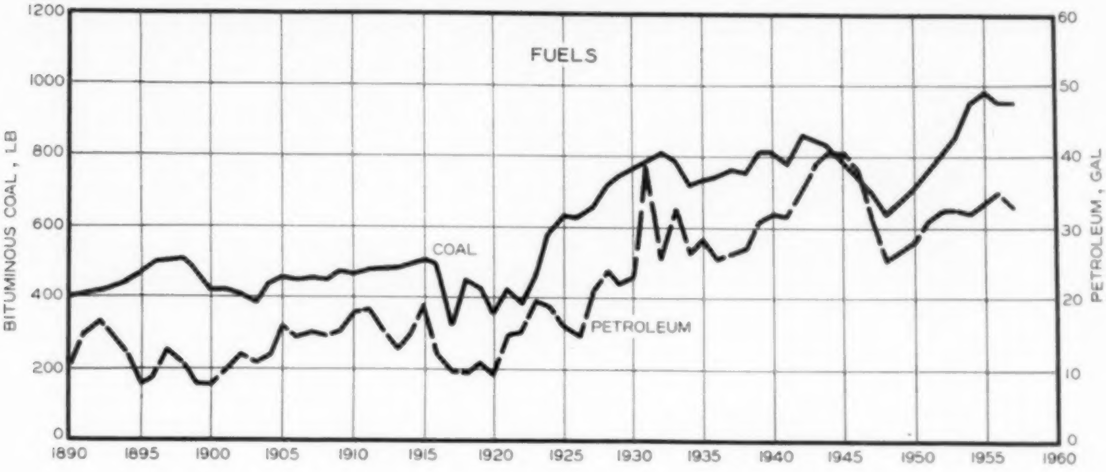
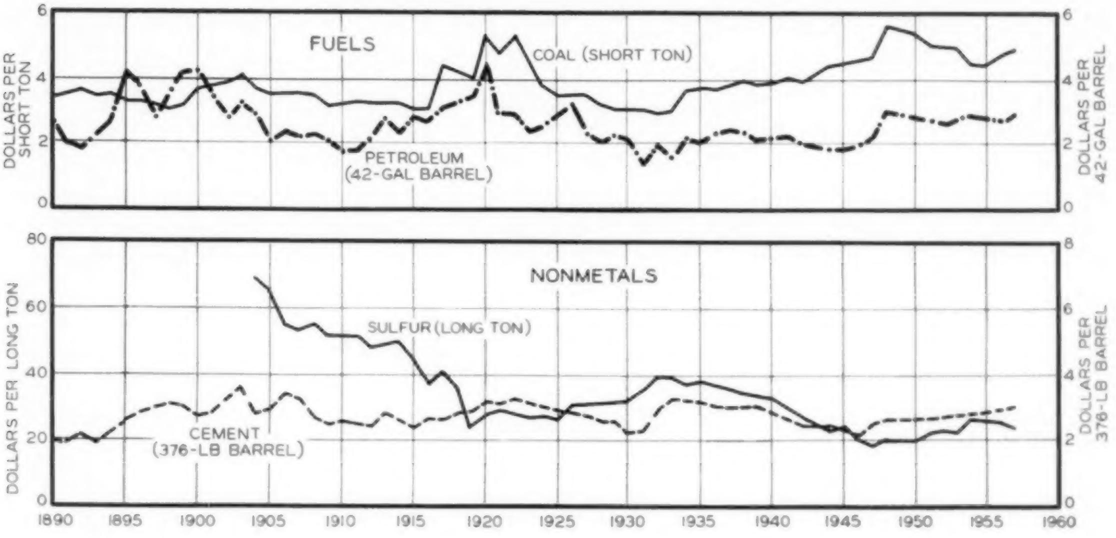


Figs. 3 and 4–Deflated prices (in 1954 dollars) of selected
Product Implicit Price Deflators used are based on the serie
1957, and on unpublished work sheets of John Kendrick fo



s purchasable for wage of one hour's labor. Average hourly acturing industries by Paul H. Douglas for 1890-1926 and ex-



ected mineral commodities, 1890-1957. The Gross National series developed by the Department of Commerce, 1929- ck for 1890-1928.

Looking Back—1958

Looking Ahead—1959

ECONOMICS

In the preceding pages you will find an attempt to judge the direction of one phase of the mining industry in Drift, and following that a quick round up of what happened to production in 1958 in Trends. Next, Charles Merrill presents a comprehensive price history for the mineral products of greatest importance, complete with figures for the past 50 years. On the following pages Nathaniel Arbiter and Charles Will Wright take a look at price trend prospects and the cold war in mining, respectively.

MINERALS BENEFICIATION

Fifty years progress is reviewed as a springboard for a look ahead. In the past decade the art has moved forward, but the author fears that the science is not progressing as promisingly.

DRILLING AND BLASTING

Here is where the "breakthrough in research" is becoming apparent. AN explosives have generated not only great interest in practical application—but more important, have stimulated study of the fundamentals of the explosive reaction. We know the how, and are learning the why. Closely coupled with explosive know-how is the continued surge in drilling technique—better as well as bigger. Down-the-hole, rotary, percussion on mounts—all are competing for the job. And again,

SHAFT SINKING

The most dramatic operation in mining (and the costliest per foot), is shaft sinking. Here too, 1958 marked strides in sinking big shafts better, and important to many mines, in sinking small shafts more like big ones.

AIME President 1959

Howard C. Pyle, President of The American Institute of Mining, Metallurgical, and Petroleum Engineers for 1959, obtained his first practical knowledge of the oil industry 35 years ago while working as a roustabout in the oil fields during summer vacations from college.

Mr. Pyle was born in Williams, Ariz. April 8, 1904. He moved to Pasadena, Calif., with his parents the following year, and has continued to make his home in the Golden State. A graduate of the Pasadena elementary and high schools, he attended the University of California, receiving a Bachelor of Science degree in petroleum engineering and geology in 1926. Subsequently, he earned his master's degree in petroleum engineering, and the professional degree of petroleum engineering from the University of Southern California in 1939 and 1941, respectively.

From 1927 through 1942, M. Pyle was employed by the Union Oil Co. of Calif. as an exploration geologist and petroleum engineer with the position of chief production engineer during the latter part of that period. As a geologist he worked in Venezuela and California with occasional assignments in Oregon, Washington, and Canada.

During this period, Mr. Pyle presented technical papers before the AIME and the American Association of Petroleum Geologists, and served as chairman of the American Petroleum Institute Production Div. in California, from 1937 to 1938. He was a member of the Conservation Committee of California Oil Producers Committee and a member of its allocation committee, heading it in 1942.

During World War II, Mr. Pyle served with the US Army Corps of Engineers, first in Washington, D. C., and then as petroleum officer on General Eisenhower's staff in the European Theater, advancing to the rank of lieutenant colonel. During the early invasion period when Field Marshal Montgomery commanded the allied troops, Mr. Pyle served on his staff, returning to his former post when General Eisenhower assumed direct command in August 1944.

From September 1945 to November 1947, he was vice president of the Bank of America in California, in charge of the bank's oil industry loans. For the next three years he was president of Continental Consolidated Corp., oil producers. Following a short period as an independent petroleum engineer, Mr. Pyle was elected president, director, and chairman of the executive committee of Monterey Oil Co. in November 1951, positions which he holds today.

The new AIME President was elected to membership in the Institute in 1941 and from that time on has been active in its affairs. In 1947 he served as Chairman of the Petroleum Branch, now the Society of Petroleum Engineers of AIME. He was elected to the AIME Board of Directors in 1955, and has continued as a member of the governing group.

Mr. Pyle also is a director of the American Petroleum Institute, the Western Oil and Gas Association, and is a member of the American Association of Petroleum Geologists, Theta Tau, Sigma Xi, and an honorary member of Pi Epsilon Tau.

As President of the Institute, Mr. Pyle feels the objective of mineral industry unity is best served by identifying him as a representative of the Institute as a whole rather than as a member of one of its constituent Societies. This attitude is a significant omen that the affairs of AIME in 1959 will be handled judiciously and efficiently under his control.

Howard C. Pyle

by NATHANIEL ARBITER

TRENDS IN METAL CONSUMPTION AND

If the metal mining industry is to plan intelligently, it must estimate future consumption. Conventional procedure is to extrapolate arbitrary smooth curves drawn through past consumption data, with little regard to reliability of results. The purpose of this article is to report the findings of a statistical study of steel, copper, lead, and zinc consumption and prices over a large part of this century. It will be shown that per capita consumption can be correlated adequately by linear trend lines. The assumptions and uncertainties in developing the trends are considered. It will also be shown that although actual price forecasting is impossible because of currency fluctuations, the price ratios for copper, lead, and zinc relative to steel permit definition of a normal price for each of these metals relative to a prevailing steel price.

Problems in Forecasting Metal Consumption: Annual consumption data alone are inadequate for estimating future requirements of a metal. Continuing growth in the country's population requires the use of per capita consumption data instead, and the basing of forecasts on extrapolation of these figures and on estimates of future population. Thus any forecast involves both the demonstration that a trend exists in past data for consumption and for population, and the assumption that these trends will continue unchanged into the future, or that trend changes can be predicted. Since the latter possibility is unlikely, it will be assumed that present trends will continue without change.

Population Estimates: To obtain the estimates of future population, laws of growth developed from the study of simple systems such as bacteria colonies have often been used. Growth curves for these systems may fit equations such as those of Gompertz or Pearl-Reed. But applying these equations to population growth led to the obviously false conclusion that U. S. population would level off in this century without reaching 190 million.

Population growth is much more complex than that of the systems described by simple growth laws. For example, U. S. Census figures since 1790 do show a long-range decline in the growth rate. Starting at 3.5 pct per year for the 1790-1810 period, the rate reached 1.6 pct per year by 1930, and 0.70 pct by 1940. But for the decade ending in 1950, the rate increased to 1.95 pct per year. Similar short-range discrepancies also characterize earlier periods. While extrapolation of the long range trend does suggest a further decline in growth rate, it is apparent that unpredictable factors can cause abrupt, short-term deviations from this trend.

While population growth is a biological phenomenon, it can be affected both by medical-sociological and economic factors. For example, the birth rate decreased steadily from 1915 to 1935 but has increased steadily since then. The death rate, which was 17.2 per thousand in 1900, averaged 9.4 per thousand in the past five years. In the other category, the sharp decline in overall growth rate in the 1930's was certainly due in part to the depression, and the equally abrupt increase in the 1940's to the war. The present recession has already made itself felt in a decreased marriage rate, slight in some areas, but as much as 20 pct in others.

In the face of these uncertainties affecting short-term trends, U. S. Census Bureau projections of the population in Table I depend on recent fertility levels. The maximum figures of 229 million for 1975 assumes that the 1954-1955 level will continue; the minimum figure of 207 million assumes a return to pre-war levels. Although there is no present basis for criticizing these estimates, continued medical advances and a high level of prosperity on one hand, or severe depressions on the other, could significantly affect their reliability.

STEEL

Trend in Past Consumption: Per capita steel consumption is shown in Fig. 1 in the form of five-year averages about each year since 1905. This method of plotting tends to smooth out smaller fluctuations but extends the range of larger ones.

Table I. Projections of Total Populations*

Year	Population (Millions) Maximum	Minimum
1960	179	176
1965	193	186
1970	209	196
1975	229	207

* *Statistical Abstracts of the United States, 1957*, Table No. 3.

NATHANIEL ARBITER is Professor of Mineral Engineering, School of Mines, Columbia University.

PRICES —— STEEL COPPER LEAD ZINC

The position taken in developing the per capita consumption trend is as follows. It is assumed that a simple linear trend is evident in the data in Fig. 1, and that the two World Wars and the depression of the 1930's must be considered as gross departures and disregarded in computing the trend. The main justification for this viewpoint lies in the evident continuity between the 1905-1930 and the 1945-1957 periods. In spite of discontinuities caused by the depression and the war, characteristics of the recent trend are almost identical with those of the earlier one. Further extension of this reasoning leads to separate consideration of normal years and recession years—the implications will be developed later.

Results of this method of treating the data are shown in Fig. 2, which contains all yearly per capita consumption figures since 1905. Open circles are war or recession years not used in computing the trend line (least squares) which is labeled as such. The sigma value (standard error of estimate) for normal years is 0.039 tons per capita. For a normal distribution of deviations from a trend line, about two thirds of the points should lie within the sigma limits, about 95 pct within 2-sigma limits, and 99.7 pct within 3-sigma. These limits are shown as dashed lines in Fig. 2. The data appear to be normally distributed.

The following interpretation is placed on these results. The apparent linear increase in per capita consumption of steel is a measure of the expansion of the economy. But even for normal years growth can deviate significantly from the trend, the sigma limits being a measure of the dispersion. Such deviations, either for steel consumption or for the economy as a whole, are to be expected. In the simplest engineering systems, when the attempt is made to control a process variable, it is commonly found to fluctuate about the desired level. This fluctuation, or *hunting*, is accepted as normal within predetermined limits. Only when the variable goes beyond these limits is the system regarded as out of control and a search made for the factors responsible. It is not surprising, then, that the attempt to maintain a supply-demand equilibrium for any segment of the economy results in fluctuations about a trend. By extension of this control analogy, recession years fall close to or beyond the 3-sigma

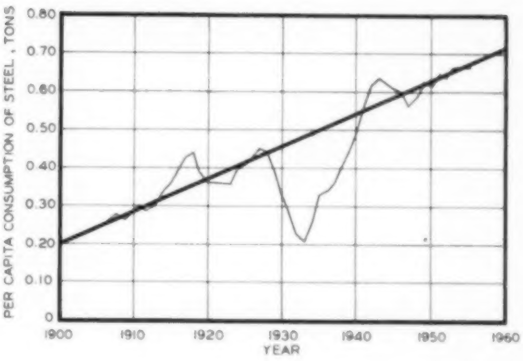


Fig. 1—Per capita steel consumption trend since 1905.

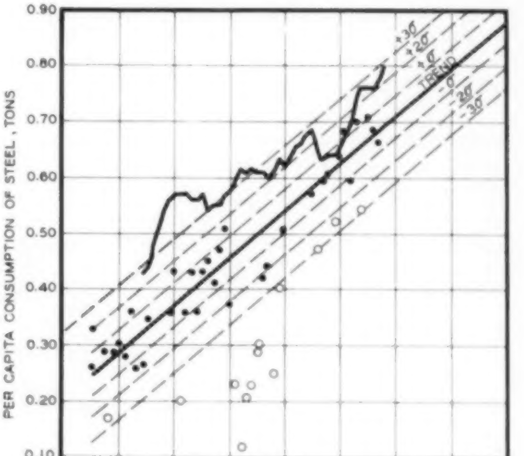


Fig. 2—The trend for yearly per capita consumption of steel since 1905. Jagged line shows plant capacity.

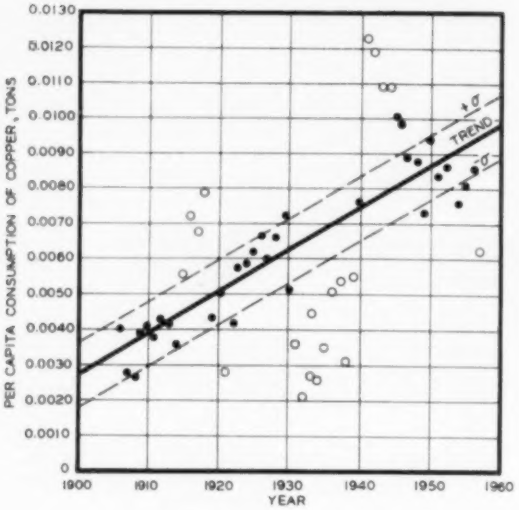


Fig. 3—Per capita consumption of copper over 50 years. Compare this with copper/steel ratio trend in Fig. 6.

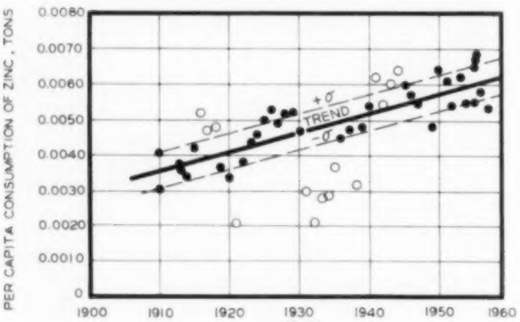


Fig. 4—Per capita consumption of zinc over 50 years. Zinc/steel ratio in Fig. 6 shows zinc consumption slower.

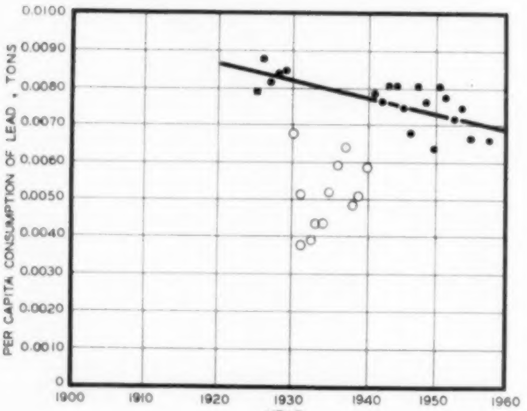


Fig. 5—Declining consumption of lead is clearly shown by comparison with data for zinc and copper in Fig. 6.

Table II. Estimated Future Steel Requirements

Year	Per Capita Consumption, Tons	Consumption, Million Tons		Plant Capacity	
		Maximum	Minimum	Maximum	Minimum
1960	0.711	127	125	146	143
1965	0.752	145	140	165	159
1970	0.794	166	156	188	176
1975	0.838	192	173	216	195

limits computed for normal years. In particular the period 1931-1939 represents a complete breakdown in control. It is also of interest that the trend computed from the mean value for the 1931-1939 period and individual values for other recession years is approximately parallel to the normal trend but about 0.11 tons per capita below it. In other words, although the data for recessions are fortunately inadequate, they appear to have a predictable severity on the average. For example, it would be estimated from the trend line for recessions that steel consumption for 1958, if this were an "average recession" year, would be about 0.55 tons per capita, consumption about 94 million tons, and operating rate about 70 pct.

Trend in Consumption and Steel Plant Capacity: The relations of actual plant capacity to annual consumption data and to the trend line are shown in Fig. 2 on a per capita basis. Since 1915 there have been four cycles of plant expansion, with peaks at 1920-1922, 1932-1934, 1945, and possibly 1957-1958. Displacements of the peaks from the trend line have been approximately 20, 16, 13, and 12 years, with an average of 15 years. Furthermore, except for the period between 1946 and 1952, plant capacity has been beyond 2-sigma limits consistently and beyond 3-sigma limits briefly after World War I. Thus there has normally been less than a 5 pct probability that full productive capacity would be required in normal years. Although the effects of the two World Wars and the Korean War on the expansion cycles are recognized, it is important to ask whether the fact that steel plant capacity, and possibly industrial capacity as a whole, runs ahead of normal requirements to the above extent bears any relation to the generation of recessions.

Apart from this speculation, the comparison is useful in estimating plant requirements. If the same capacity to consumption differential is maintained in the future as in the recent past, capacity would be about 0.10 tons per capita greater than estimated consumption.

Significance of Estimates for Future Requirements: Table III contains figures for future plant capacity requirements obtained from the extrapolated trend line, the population estimates in Table I, and the plant capacity-consumption differential.

While there are various statistical procedures that might indicate the measure of confidence to be placed in these estimates, the fact that three separate extrapolations are involved suggests that the value of the conclusions would be limited. The following conditional statements appear warranted as indicative of risks. If the linear trend continues, and if expansion is based on maximum population estimates, actual population growth at the slower rate would result in a decline in steel operating rates for normal years to 80 pct by 1975. If expan-

sion were based on minimum population estimates and growth were actually at the maximum rate, then the operating rate would approach 100 pct by 1975. The safest course would appear to be an intermediate target—for example, 205 million tons by 1975—with frequent review of both population and consumption trends and adjustment of estimates accordingly.

Two considerations lend weight to this recommendation. The maximum population growth estimate is based on post-World War II prosperity conditions. Since there is no present basis for thinking that recessions, with their probable effects on growth rates, will not continue to occur, it is only realistic to accept a figure intermediate between the maximum and minimum population growth rates. With further reference to recessions, in the period 1905-1930 only two years fall close to or beyond 3-sigma limits. In contrast, for the shorter period 1945-1958 three and possibly four years are in this category. If recessions are becoming more frequent, there would be little justification for considering them abnormal. The trend for the period 1945-1958 was therefore recalculated without eliminating recession years, and extrapolated to 1975. This indicates a per capita consumption of 0.792 tons and plant capacities of 205 million tons for the maximum population estimates and 186 million tons for the minimum figure.

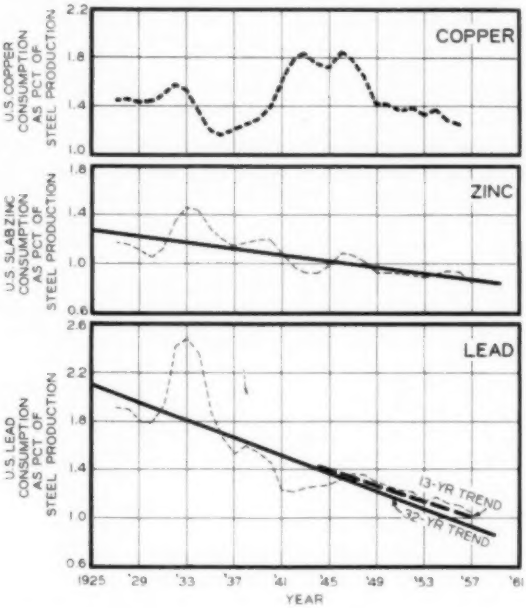


Fig. 6—Data for these trends are presented in Table III.

Table III. Nonferrous Metal Consumption, Estimated in Millions of Tons

Year	Copper	Lead	Zinc
1960	1.73 to 1.76	1.21 to 1.23	1.11 to 1.12
1965	1.94 to 2.03	1.24 to 1.28	1.22 to 1.26
1970	2.16 to 2.31	1.26 to 1.35	1.33 to 1.42
1975	2.41 to 2.66	1.29 to 1.43	1.46 to 1.62

* Note: Because of the range of tonnage the second decimal figure is not considered significant.

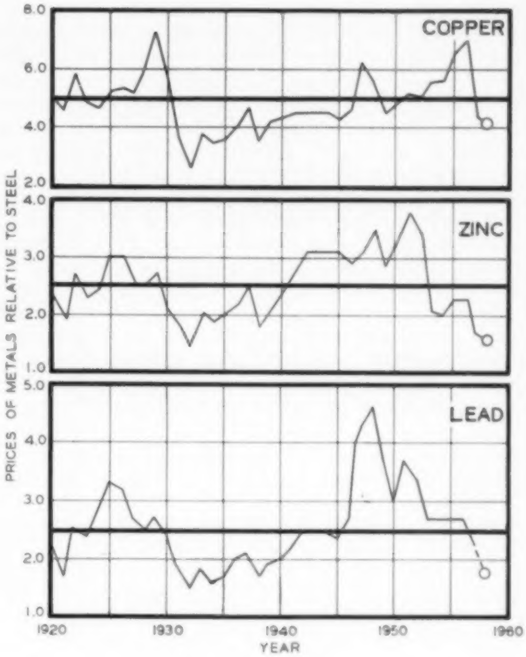


Fig. 7—Three price trends relative to price of steel.

In summary, treatment of recessions as infrequent occurrences leads to a projected steel plant capacity of 195 to 216 million tons for 1975, depending on the population growth rate. Acceptance of recessions as part of normal growth leads to a requirement between 186 and 205 million tons. Cautious optimism favors the 195 to 205 million-ton range.

One of the imponderable and dangerous aspects of forecasting is its effect on the attitude of decision-making agencies toward economic growth. Confidence in growth and the decisions based on this confidence in themselves stimulate more growth. Lack of confidence may contribute to recessions. The safe course is to eliminate non-objective attitudes and to avoid the twin pitfalls of over-expansion and excessive caution. This in turn requires continued evaluation of trends.

CONSUMPTION TRENDS FOR COPPER, LEAD, AND ZINC

As in the case of steel, projecting the per capita trend lines for copper, lead, and zinc (Figs. 3-5) permits estimation of future requirements, subject to the limitations already discussed. These estimates are summarized in Table III and refer to requirements for *normal* years. No attempt is made to convert consumption requirements to plant requirements because of the complications introduced by partial dependence on imports.

The trend lines in Fig. 6 show directly the relative growth rates of each metal with respect to steel and, by comparison of slopes, the comparative rates within the group. These are discussed separately for the individual metals.

Copper: The 50-year per capita trend for copper appears to show almost the same percentage growth as for steel. On the other hand, the copper/steel ratio trend in Fig. 6 suggests a possible decline in the ratio from 1949 to 1957. The depres-

sion and war years are not indicative because of the greater sensitivity of copper to both abnormalities. Some effect of the competition of aluminum with both copper and brass should now be apparent, and the 1949-1957 trend may be evidence for this. This period is too brief, however, to be conclusive in view of the violent fluctuations preceding it.

Zinc: The per capita trend line in Fig. 4 and the zinc/steel ratio trend in Fig. 6 both indicate that zinc consumption has not grown as rapidly as that of steel. The increase for steel during this century is in effect one measure of the expansion of the economy. It reflects both new uses for steel and more old uses of the metal. Failure of a metal such as zinc to keep pace with steel suggests less versatility for the applications of the metal and greater vulnerability to competition by other materials. Although aluminum has not been a factor over the entire period represented in Fig. 6, its present competition with zinc in industries using die-casting, brass, and galvanized iron may accentuate the trend.

Lead: The trend in per capita consumption of lead differs markedly from that of the other metals, Fig. 5 suggesting that an actual decline has taken place since 1925. Further evidence for the weaker position of lead is presented in Fig. 6, which shows a steeper decline in the ratio to steel than that of zinc. The problem with lead is greater vulnerability to competition, both in its metallic and chemical uses. Major efforts by the producers to find new uses appear necessary to offset the trends.

Metal Prices: Long-range forecasting of metal prices appears to be impossible in view of unpredictable currency instability. As an alternative the prices of copper, lead, and zinc can be expressed in such a way that effects of dollar inflation or deflation are largely eliminated. This is accomplished by using the ratios of annual prices to steel prices. Steel price is adjusted almost entirely to meet changing costs of production with little manipulation to influence the supply-demand balance. Instead the steel production rate is varied from week to week as demand indicates.

With the major nonferrous metals, on the other hand, prices are adjusted frequently according to trends in orders and stocks. Adjustment of output usually requires a severe supply-demand unbalance.

These opposite pricing policies reflect differing economic philosophies as well as differing structures in industries. The steel industry does not have important foreign competition in the domestic market except for a limited number of products. Production is based on a large number of individual units, which makes for flexibility in control through variation of the number of units in operation. In contrast, production of copper, lead, or zinc is obtained from proportionately fewer units. For this reason and because of the nature of the production processes, rapid adjustment of output to demand is more difficult. In addition, the U. S. is not self-sufficient with respect to any of these metals. If the attempt were made to maintain their prices and to adjust production rates more frequently to balance supply and demand, foreign competition would have to be reckoned with. Without some form of import control, lower-cost foreign metal would defeat this method of seeking market stability.

The general pattern of steel and of copper, lead, and zinc prices since the end of World War I permits suggesting a *normal* price for each of the nonferrous metals. In Fig. 7 the price ratio of each metal relative to steel is given for each year since 1920. This treatment assumes that the price of steel is an appropriate measure of the industrial cost of living, in that it reflects both real changes in production costs and changes due to dollar fluctuation. If the prices of the other metals responded only to these effects, the ratios would be relatively constant. This is obviously not the case. Instead, these metals as a group appear to react more severely to economic unbalance than does steel, probably as a direct consequence of the attempted use of price to control the market balance.

In addition to the short-term fluctuations, there have been two long price cycles since 1920: the first from 1920 to 1932 and the second from 1932 to the present. The first reached peaks between 1925 and 1929 and the second in 1948 for lead, 1951 for zinc, and 1956 for copper. These cycles are interpreted as long-term shifts in supply-demand disequilibrium, since prices of these metals are determined primarily by this consideration. The ascending part of each cycle reflects the increase of demand at a greater rate than supply, and the descending part the opposite condition. In both cycles copper reached its peak later than lead or zinc, and it reached the same price relative to steel. Of particular interest is the fact that lead and zinc are now almost as low relatively as they were in 1932, while copper would have to drop to 16¢ to equal its 1932 low.

Average price ratios for the two cycles are almost identical (Table IV). This suggests that these

Table IV. Average Metal Prices Relative to Steel

Metal	Relative Price		Average
	1920 to 1932	1932 to 1957	
Copper	5.0	4.8	4.9
Lead	2.5	2.6	2.6
Zinc	2.4	2.6	2.5

average relative prices provide a reasonable definition of a normal price for these metals. In the absence of drastic real changes in production costs or use* they provide a means for estimating the probable equilibrium prices for the metals with supply and demand in balance. For example, the current composite finished steel price is 6.2¢ (Sept. 18, 1958). Hence current equilibrium prices for the three metals are: copper, 30¢; lead, 16¢; and zinc, 15.5¢.

* The use of price ratios does not distinguish between changes in demand due to general economic cycles and changes due to gain or loss in market through competition with other materials.

Fig. 7 indicates that while these price ratios have cycled about the average with no evident trend, the average price ratios have rarely obtained except in passing. If price stability is a measure of control, then it is apparent that such control is lacking. In view of the complex involvement of domestic prices with world supply-demand balance and with world politics, no position is taken here on the possibility of better control. However, it is suggested that an effective measure of such control would be to reduce the amplitude of the cycling of price ratios about the long-term averages.

FREE WORLD NATIONS MUST CONSOLIDATE ON METAL REQUIREMENTS

It is clear that all the Free World nations should be apprehensive about their industrial needs for metals in the next five or ten years. Will future output from present world sources, and from those to be discovered, supply the world's industries with the metals needed for their growing populations and the demand for better living standards?

by CHARLES WILL WRIGHT

In *Resources for Freedom*, published in June 1952, the Paley Commission gives a general analysis of potential metal production, consumption, and ore reserves of the principal industrial nations. The situation is also discussed in reports of the Mid-Century Conference held in Washington in December 1953. Both the Paley Commission and the Mid-Century Conference pointed out ways to improve the position of the Free World nations, but little has been done to implement these suggestions or to establish a definite U. S. mineral policy.

Appraisals of the Paley Report are scheduled for presentation at a session of the Council of Economics during the February 1959 Annual Meeting of AIME.

Chance for Improvement: In July 1958 an international group of 12 unofficial specialists in mineral economics met in Paris under the chairmanship of M. André Siegfried of the Academie Française to discuss the present situation and future outlook for mineral requirements, production, ore reserves, and factors impeding access to the sources of supplies. The group* reached agreement on several important points and recommended that public attention be called to the urgency of adopting measures to improve the position of Free World industrial countries with regard to mineral supplies. Specifically, their conclusions were as follows:

* Participating members at this meeting were F. Blondel, F. Ventura, and G. Perrineau of France; E. W. Pehrson of the U. S.; G. C. Monture of Canada; F. F. Hast, F. W. Friedensberg, and E. Plotski of Germany; R. Satori of Italy; F. Evard of Belgium; and G. L. Blokhuis of Holland.

C. W. WRIGHT was formerly Chief of the Mining Division, U. S. Bureau of Mines, and Chief Foreign Mineral Specialist attached to the Department of State.

1) It is not the exhaustion of minerals that is to be feared, but rather the growing danger of conflicts between governments, producers, and consumers arising from ignorance or misunderstanding of mineral economics.

2) There should be international collaboration for greater economic well-being, which depends on a continuing flow of mineral products where they are needed.

3) Because they are natural resources essential to higher standards of living for mankind, mineral products should be subject to only minimum restrictions of trade.

4) Greater exchange of raw mineral products for manufactured products is vital to all countries of the Free World.

5) As living standards improve, the need for metals will increase quite out of proportion to the regular growth in population.

6) The expectations of finding new orebodies are more favorable in the underdeveloped countries, where technical services and capital are inadequate.

7) To attract private capital, it is essential that investment be granted a favorable and secure climate* and that agreements voluntarily negotiated be held inviolate for the period for which they are concluded.

* Ed. Note: See Evan Just's article, "Foreign Private Investment—A Boon to Developing Countries," published in MINING ENGINEERING, June 1957.

Since huge sums of money are required to bring mineral deposits to the production stage, it was rec-

U. S. Self-Sufficiency in Metal Production, 1956 and 1957*

Ferrous Metals		Production	Consumption	Self-Sufficiency, Pct	Imports	Eastern Hemisphere, Pct	Western Hemisphere, Pct
Iron ore,	1956	97,849	125,171	78	30,411	8	92
1000 Lt	1957	135,000	105,386	78	33,653	6	94
Manganese ore, 1000	1956	345	2,264	15	2,222	69	31
tons	1957	325	2,106	15	2,780	56	44
Chromite,	1956	162	1,847	9	2,175	98	2
1000 tons	1957	166	1,572	7	2,064	96	4
Nickel,	1956	7,392	127,578	6	142,642	10	90
tons	1957	10,070	122,466	8	140,000	10	90
Cobalt,	1956	3,595	9,562	38	15,577	92	8
1000 lb	1957	3,198	9,156	36	17,450	87	13
Tungsten,	1956	14,761	9,061	163	20,860	43	57
1000 lb	1957	8,032	8,544	94	14,018	33	67
Zirconium,	1956	44	70	60	31	98	2
1000 tons	1957	57	85	68	42	100	0
Nonferrous Metals							
Bauxite,	1956	1,743	7,751	22	5,670	1	99
1000 Lt	1957	1,416	7,763	19	7,101	0	100
Copper,	1956	1,106	1,367	81	596	20	80
1000 tons	1957	1,077	1,250	86	574	21	79
Lead,	1956	353	839	42	494	44	56
1000 tons	1957	333	1,108	30	531	47	53
Zinc,	1956	542	1,221	44	708	2	98
1000 tons	1957	520	1,234	42	794	19	81
Antimony,	1956	1,910	12,897	15	13,197	48	52
tons	1957	709	11,189	6	9,100	52	48
Mercury,	1956	24,177	54,143	45	47,346	75	25
flasks	1957	33,380	50,889	63	42,005	87	13
Tin,	1956	0	60,470	0	79,278	88	12
Lt	1957	0	54,500	0	56,200	100	0
Platinum,	1956	21	850	2	1,034	69	31
1000 tr oz	1957	19	746	2	637	59	41

* Statistics supplied by the U. S. Bureau of Mines.

Comments: Certain U.S. metal deficiencies are due in part to the lower cost of imported ores, which has discouraged domestic mine output, and in part to the lag in increasing the nation's mineral reserves. By more intensive exploration with geophysical methods, diamond drilling, and metallurgical research, new sources for the various metals will be made available and commercial grade ore will be recovered from the known extensive low grade ore deposits. If this is done, the U.S. may eventually become more self-sufficient in production of manganese ore, chromite, tungsten, and copper and may better its position in lead and zinc.

Of particular interest is U.S. production of steel ingots and castings—115,216,149 tons in 1956 and 112,714,996 tons in 1957. Output of the USSR was 53,572,000 tons in 1956 and 56,218 tons in 1957. Steel output in 1958 in both the U.S. and USSR will show considerable increase. In 1957 Free World production was 75.6 pct of the world total.

ommended that governments of all countries adopt fiscal policies in reference to the rate of amortization of investment and avoid levying high taxes on profits in periods of high prices without giving due consideration to losses in periods of low prices. It was also recommended that government-financed buffer stocks be established for better price stability; this would allow mineral industries to operate on a continuing economic basis and would safeguard the welfare of communities dependent on mineral activities.

Proposed Study to Consolidate the Free World's Position in Metals: The accompanying table on U. S. Self-Sufficiency shows this country's production and consumption of the principal ferrous and nonferrous metals. For industrial consumption in 1957 the U. S. imported large percentages of its total requirements of the following metals:

Chromite	94 pct
Manganese	85
Tin	100
Antimony	94
Beryllium	90
Lead	70
Zinc	58
Mercury	51

This shows how dependent we are upon foreign sources to meet the present needs of our industries. The percentages of these imports are steadily increasing.

To carry out the recommendations of the mineral specialists at their Paris meeting, the statistics from all the principal metal-producing and consuming countries of the Free World should be tabulated. For this task a committee should be established, headed by the U. S. Bureau of Mines and representatives of the metal industries, to work out the mineral supply problems within the U. S. and the Free World nations, assuring a better distribution of the metals supplies to meet each nation's industrial requirements.

The USBM has much of this information from the Free World countries in its files, and what is lacking may be obtained by cooperative aid to each country's Bureau of Mines. Brief reports on the principal sources of metals and the known reserves in industrial countries should also be obtained where possible.

The proposed committee would supply this information, as received, as confidential data to the Office of Defense Mobilization, the State Department, and the World Bank. It would also cooperate with the World Bank and the International Development Fund Association, if called upon to study the importance of mining and metallurgical projects in the underdeveloped countries for which loans have been requested.

Latin America: It is most essential that arrangements be made to increase the activities of the USBM in Latin America by which its engineers will work with engineers of the local mining bureau in reporting on old and new sources of mineral supply for both local use and export to the U. S. Such a plan, if carried out, would assure us of more of the mineral products we need and would help combat the Russian trade war in Latin America.

At this time there are only five USBM engineers and two mineral attachés in Latin America. To cover the entire field there should be one or two USBM engineers in each of the mineral-producing republics, including Cuba. There should also be additional attachés.

Highlights on the Present Situation: At present there is a surplus in world production of oil and many of the nonferrous metals, but this is gradually being absorbed by increasing requirements of the industrial nations, and five or ten years from now there may even be a shortage of many of the metals.

Fortunately the large U. S. mining and industrial firms have agents in foreign fields to negotiate with mine owners for their output of certain mineral products needed in this country. But they are up against serious competition from other industrial nations, including those of the Free World. There is also a growing nationalistic tendency in the underdeveloped countries, and their resistance to foreign control of their mineral wealth is having its effect on exports to the U. S.

As to the operations of American mining companies in the non-industrial countries, they have proved of tremendous benefit to the social and cultural progress of local populations, and the taxes these companies pay support most of the financial requirements of the countries where they operate. Despite these facts, governments feel impelled to take over foreign enterprises, as they did with American oil interests in Mexico and the oil and tin mines in Bolivia. Thus existing enterprises created under a more favorable political climate are in danger of being confiscated* or of being exploited by taxation.

* **Ed. Note:** For a discussion of two types of insurance for foreign investors, see Sumner N. Anderson's article "U. S. Government Support to Mineral Industries of Latin America" in the November 1958 issue of MINING ENGINEERING.

Anticipated results on their invested capital are no longer assured.

Nations that have not the technical capacity and capital to develop their mineral resources should adjust their mining and fiscal laws to favor those willing to risk investment in developing foreign mineral deposits.

The experienced engineers of the USBM and the mineral attachés at American embassies, if properly distributed and in sufficient number, could help greatly to bring about more favorable conditions for American investments.

Proposal for Expanding USBM Activities Abroad: Plans for urgently needed foreign fact-finding in the mineral field have been retarded by the attitude of the Department of State, which has failed to recognize the importance of utilizing trained mining men in the Foreign Service. The Department of Agriculture has been successful in persuading Congress of its need for an independent foreign reporting service. Similar consideration should be given to the Bureau of Mines. Until the function of mineral reporting is placed in the hands of a competent technical agency, such as the USBM, we shall continue to falter in establishing a sound national mineral policy. Full data on foreign sources of metals, soundly interpreted by qualified experts, is no less essential than full understanding of the domestic mineral economy in present-day competition for the metals we shall require for the future.

National Mineral Policy: The U. S. unfortunately has not as yet established a definite national mineral policy, due, in part, to objections by special interests, and, in part, to conflicting concepts of the government's proper role. We have a host of agencies working independently on foreign aid and trade policies, but no overall national mineral policy. However as problems of mineral supply are better understood by members of Congress, stronger efforts will be made to establish an effective national mineral policy. Russia *already* has an effective mineral policy.

THE VITAL ROLE OF METALS IN A NATION'S INDUSTRIAL MILITARY WELFARE

by CHARLES WILL WRIGHT

With steadily increasing requirements for civilian use as well as for defense, the U. S. is becoming more and more dependent on foreign sources for many essential metals. Until now it has been possible to import these metals at favorable prices. But other countries are awakening to the benefits of industrialization and are expanding their manufacturing facilities. Their demands on the world's metal resources will intensify, and the U. S., the largest consumer of metals, may soon find it difficult to acquire the imports needed for its industries. Our greatest weakness is that at present there are not enough known commercial deposits within our borders to satisfy increasing demands.

The Russians, to meet their deficiencies, are carrying out intensive development of mines behind the Iron and Bamboo Curtains and are increasing output of metals each year. Since the restrictions on exports of strategic products to the Sino-Soviet bloc were lifted, they have also increased their imports of the needed metals, thus adding to their industrial power. These facts are of major importance in reshaping world trade patterns to the advantage of the Communists and should warn the Free World of the reality of Russia's economic offensive.

Steel Industry: The high standard of living we enjoy and our present position in world affairs has been based in large measure on the vast, easily accessible iron ore and coking coal resources that supply our steel industry. Steel is the essential ingredient of modern industrial power. Among the six leading steel-producing nations, the U. S. accounted for 35 pct of the world's output in 1957; the USSR, 17.5 pct; West Germany, 8.5 pct; United Kingdom, 7.5 pct; France, 4.8 pct; and Japan, 4.5 pct. The Free World total was 75.6 pct and that of the Sino-Soviet bloc 24.4 pct.

Vital to steel products—particularly the special types for munitions, jet planes, and missiles—are the ferroalloy metals, which are called upon to resist high temperatures, impart hardness, or fulfill other requirements. In 1957 Free World production of these metals, in percentages of world output, was: iron ore, 75.4 pct; manganese ore, 53.4 pct; chromite, 81 pct; nickel, 82.5 pct, and tungsten, 55.7 pct. Much is being done to increase the manufacture of steel products in both the Free World nations and those of the Sino-Soviet bloc.

Nonferrous Metal Industries: Nonferrous metals also have an important part in a nation's industrial and military welfare, and here too the output from mines in the Free World areas is several times greater than from mines behind the Iron and Bamboo curtains.

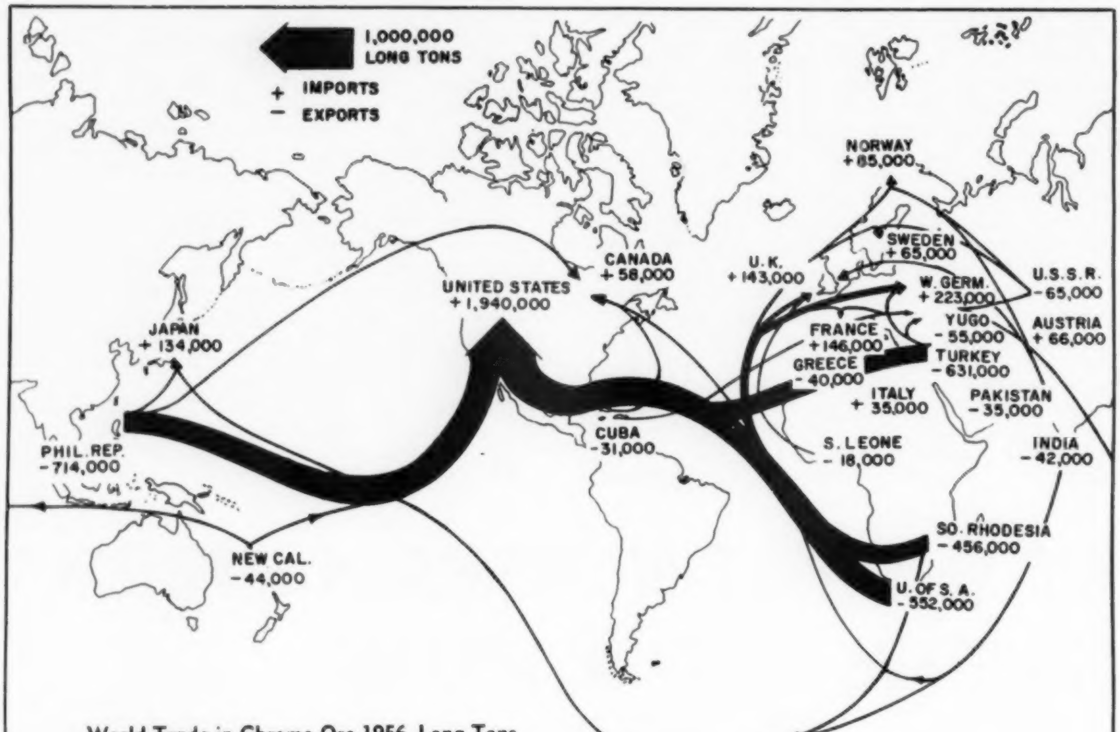
The Free World's production in 1957, in percentages of world output, was as follows:

Aluminum	83.3 pct
Antimony	65.5
Cadmium	92.2
Copper	87.1
Lead	81.9
Mercury	82.9
Platinum	89.5
Sulfur	97.5
Tin	84.9
Zinc	81.4

The U. S. contribution to this total was: aluminum, 44 pct; copper, 28 pct; lead, 13 pct; zinc, 15 pct; mercury, 14 pct; and sulfur, 75 pct.

U. S. Program to Acquire Needed Metals: To meet this country's industrial needs during the next few years, the U. S. Government has been purchasing foreign metals and minerals at relatively low prices and domestic supplies at fixed prices and is stockpiling essential products for emergency requirements.

In accordance with the Mutual Security Act, the International Cooperative Administration is doing



World Trade in Chrome Ore 1956, Long Tons

an efficient job in financing more extensive mineral surveys in foreign fields. Under direction of the USGS and USBM, American geologists and mining engineers are being sent to both the eastern and western hemispheres to work together with geologists and engineers of the local mine departments. The field investigations and development work being done on new ore deposits are opening up sources of metal supply for local needs and export to the U. S.

But most important is the economic program to which Secretary Dulles referred in his address to the UN General Assembly on September 17th. This is now being studied by C. Douglas Dillon, Undersecretary of State for Economic Affairs, together with the heads of the World Bank, the International Monetary Fund, and the Export and Import Bank. The plan envisages the establishment of an International Development Association, affiliated with the World Bank, to guide the flow of capital where it is needed most. This should include the development of new sources of mineral supply for local use and for export to the U. S.

Russia's Competition for Mineral Imports: The need to import metals for the expansion of Soviet industry has been one of the reasons for Russia's trade war. A secondary reason is Russia's attempt to block U. S. imports of certain raw minerals essential to this country's industrial progress.

Russia's continuing activities in the metal-producing countries are showing their effect. According to report, Russian trade agreements concluded since 1954 with the underdeveloped countries amount to $2 billion in credits for the purchase of goods and services.[1] Long-term loans are offered to the borrowing countries at 2.5 pct interest, repayable in local currencies or commodities. "The Russians," writes W. A. Nielson, "now have the means, the will and the skill to conduct a vigorous economic war, and the underdeveloped countries are their prime targets."[1] Already representatives from their mining and manufacturing firms are scattered over the globe, negotiating with mine owners for raw minerals in exchange for mine equipment, power, and metallurgical plants. They are evidently quoting prices and taking chances that our private mining and manufacturing firms will not accept. Competition against such totalitarian system is making it increasingly difficult for American manufacturing firms to sell their products and for American mining companies to acquire mining interests in these countries.

Recently there have been many brilliant and realistic appraisals of our position. It has been pointed out that Russia's economic offensive may prove to be more dangerous than her armies. Her ideological offensive may be even more dangerous than the economic one.

The future is not unalterably determined. There is every reason to believe that with their greater manufacturing capacities and their preponderance in production of steel and many other metals, the countries of the Free World hold the trump cards and will win a showdown with Russia if they play these cards wisely.

REFERENCE

[1] W. A. Nielson: Why We Are Losing the Ruble War. *Harper's Magazine*, September 1958.

MINERALS BENEFICIATION

1908/1958

by NATHANIEL ARBITER

Minerals beneficiation developments in 1958 have been dominated by effects of the economic recession in durable goods. Starting in 1957 cutbacks were severe in mining exploration and development. Retrenchment in production of mineral raw materials soon followed, and by the first few months of 1958 the impact was felt throughout the industry. Complete shutdowns of smaller mills and shorter workweeks for larger operations were common. Unemployment was serious among professional and operating personnel.

Rather than take stock of detailed developments in beneficiation, which were on reduced scale, this review will deal with the present state of practice. Periodic stocktaking of this type can be a measure of progress and a guide to future developments. An attempt will be made to trace in broad outline the changes in practices over the past 50 years. A convenient starting point for this purpose is Richards' *Ore Dressing* (Sec. Ed., 1908), which was based largely on turn-of-the-century practice.

Primary Crushing: In the crushing field, at that writing, handbreaking was still surprisingly important. Steamhammers and drophammers had been developed and were used principally on native copper ores. The gyratory breaker was available and was reported to be superior to the jaw crusher for large-capacity operations; however, Richards' flowsheet section mentions only two or three plants actually using the gyratory. By way of explanation, his flowsheet data had been collected in the summer of 1895, while his text, which was completed by 1903, does mention the increasing adoption of gyratories, particularly for large operations.

With respect to crusher sizes, the largest jaw crusher mentioned by Richards was a 24 x 36-in. machine at the Calumet and Hecla mill in Michigan. Most mills used 6, 8 or 10-in. machines. The largest gyratory listed was 18 x 126 in. These small sizes

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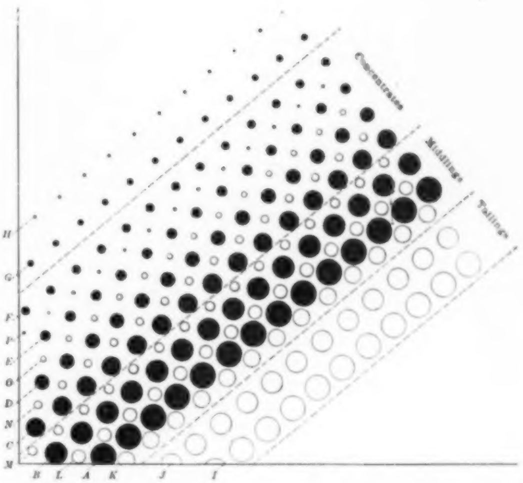
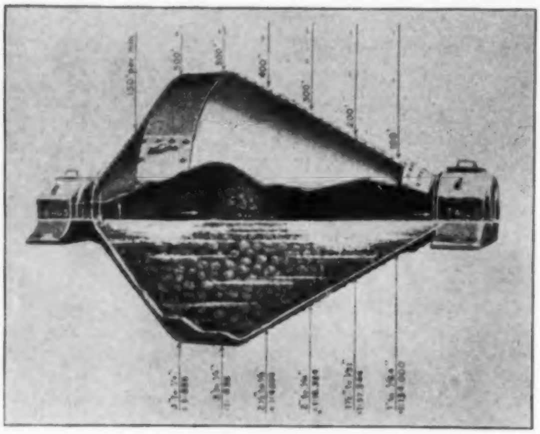


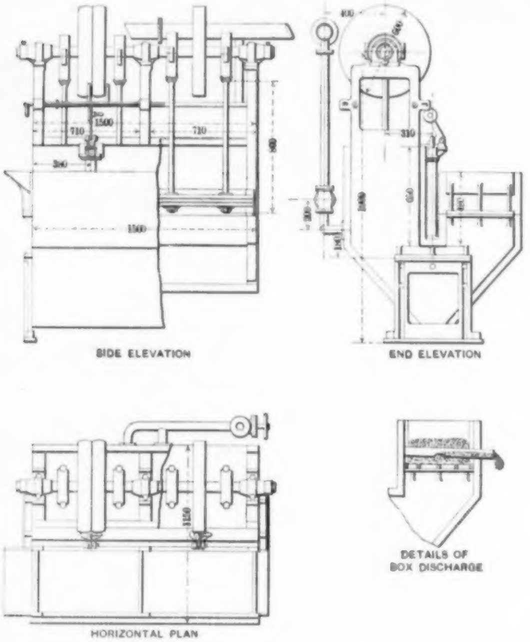
This idealized diagram is from a paper by Professor Richards analyzing the performance of the Wilfley table. AIME Transactions, Vol. 38, 1908.

reflect the small mill sizes of the day. Of 79 mills for which Richards gave capacities, 53 were under 200 tpd, 10 between 200 and 400 tpd, and only 6 mills over 1000 tpd. By 1927[1] coarse crushing had not changed in principle from Richards' first writing. By then the gyratory was widely used, and its position relative to the jaw crusher was established. The jaw crusher was available in sizes up to 84 x 120 in. and the gyratory up to 72 x 484 in., although none of these large machines were in actual use. Concentrators for porphyry coppers had reached the 20 to 30-thousand ton capacity, and the farsighted but unsuccessful Mesabi Iron Co. taconite mill was in the same range.

Today's maximum scale of operations is about double that of the 1920's and ten times what it was 50 years ago. At least three of the porphyry coppers



H. H. Hardinge discussed his new mill in a paper in AIME Transactions, Vol. 39, 1909.



Jigging, gravity treatment perennial, is analyzed here in a paper dating from 1909.

run at about 50,000 tpd, and ultimate capacities for several taconite plants are to be 50 to 60 thousand tons. Primary crushing, however, has actually remained unchanged with respect to machine types for about 75 years, and with respect to machine sizes for 30 years.

This raises the question of whether any important changes should be anticipated. Probably not in the near future. In the porphyry copper field—with the exception of the Morenci mill, which was expanded to 50,000 tons from the original 30,000-ton capacity—none of the more recent plants have been built to handle more than 30,000 tpd. Gyratories with 60-in. gape are adequate for those capacities. A similar size has been adequate for the Reserve and Erie taconite plants. Although there is current speculation that 72-in. machines will be built, this size would be required to work with 8-cu yd shovels, rather than from capacity considerations.

In another direction, there has been discussion in recent years as to the possibility of greater fragmentation through changes in blasting procedure, with reduction in primary crusher size requirements. This would depend on the relative efficiencies of size reduction by blasting as compared to crushing—a little known subject, on which experimentation would be difficult and costly. From the dollar viewpoint, crushing costs in large operations are generally so low * as to discourage innovations.

* Under 5¢ per ton at one plant from run-of-mine to $-\frac{1}{2}$ in., including screening and conveying.

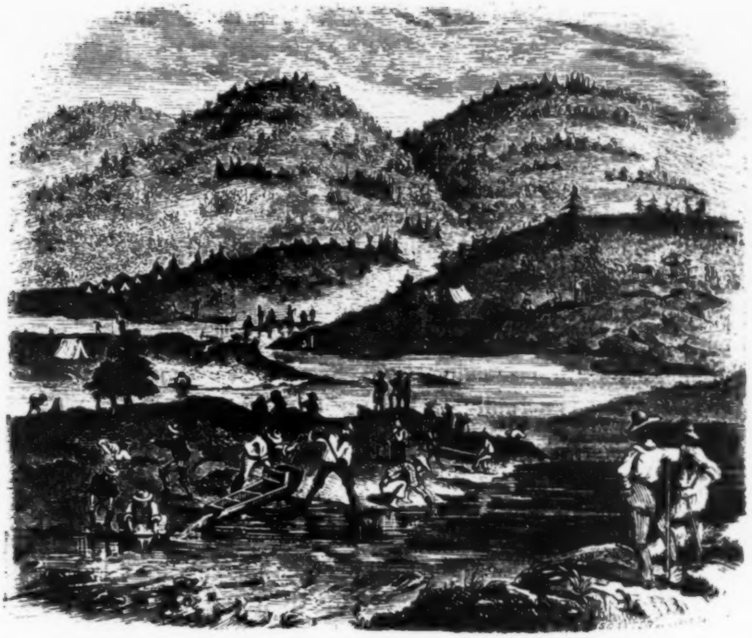
Secondary Crushing: In the period 1895-1905 secondary crushing meant roll crushing or stamp milling. As mill capacities increased and primary crusher sizes increased along with them, the limiting size of crusher products increased from the 1 to 2-in. range up to the 12 to 14-in. range. This in turn required developing secondary crushers with large enough openings to receive such feed sizes and capacities sufficient to handle tonnages without undue multiplication of units. The problem was first solved, after a fashion, by using smaller gyratories or jaw crushers or rolls; later, by curving the crushing members of the jaws and gyratories to develop the reduction crushers; and finally, in the mid-twenties, by developing the cone crusher.

These, within a few years, had so pre-empted the secondary field on hard ores that the standard flowsheet became jaw crusher or gyratory (depending on mill capacity) followed by one or more stages of cone crushing (depending on run-of-mine size and finishing size). By this time the stamp mill—never widely used in base metal gravity plants because of its sliming characteristics—was also disappearing from gold mills. It had reached its maximum use with free-milling gold ores for which amalgamation and gravity methods sufficed. With the growing preponderance of lower grade and more disseminated ores, after the advent of the cyanide process, the stamp could not compete with the tumbling mill for the finer grinding duty in any but the smallest mills, and ultimately it became extinct.

Use of the roll crusher, which around 1900 had been almost universal in the base metal mills, became circumscribed, first by the tumbling mills and later by the cone crusher. Today it is rarely found in concentrators, but it retains a significant use in dry crushing to achieve finer products than are possible with cone crushers.

Of the wide variety of fine crushers and pulverizers developed in the late nineteenth and early twentieth centuries (Richards listed 23 classes of machines with 86 separate types), most have disappeared from hard rock milling. Others, such as the various toothed rolls and the hammermill, still retain a definite place for special application—crushing softer rocks, handling sticky materials, and producing uniformly shaped fragments. The only machine in this category with an expanding use on ores in recent years is the impact breaker, which is a double-hammer mill. These, under various names, have been used fairly extensively in Europe and in Africa since World War II but have had little application in the U. S.

With regard to future trends, the only development likely to affect the dominant role of the cone



Simply titled "A Mining Scene," this view goes back not 50, but 100 years. Beneficiation has made tremendous strides, but gravity methods like those shown here endure in much refined form.—Bancroft Library, Univ. of California.

crusher is autogenous grinding. The largest settings of current primary crushers are in the 12 to 14-in. range, turning out a product of 20-in. maximum size. There is increasing evidence that feeds of this size can be treated in a tumbling mill of appropriate diameter and design to yield a product comparable in size to present rod or ball mill products. Depending on the breaking characteristics of the ore, this may require no grinding medium other than the ore itself; occasionally, if intermediate sizes tend to build up, some proportion of grinding balls may be necessary. Further details are given below. The approach seems inherently sound, and future activities should be interesting.

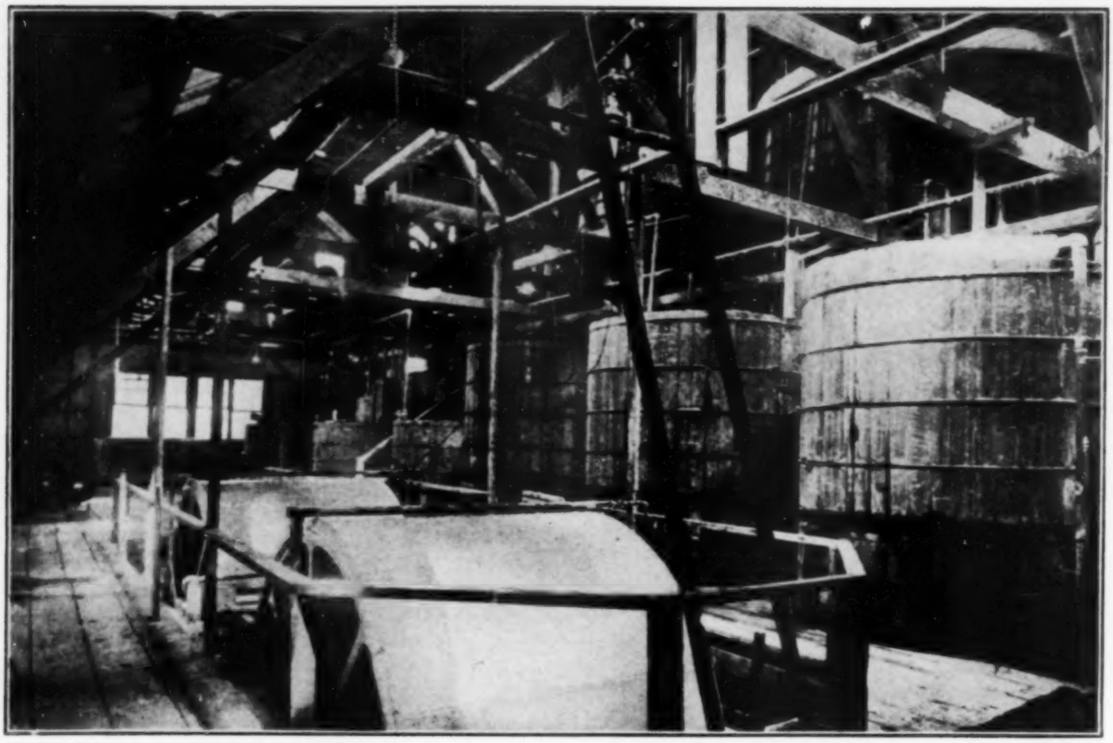
Grinding: In 1908 Richards noted: "Several other fine pulverizers are competing for the place occupied by the gravity stamps, of which prominent examples are . . . ball mills." Since then, of course, the ball mill and related rod and pebble mills have completely displaced not only the stamp but all other grinding machines from ore treatment plants. Principal progress with tumbling mills has been the development of large-diameter machines and new design features and the use of closed circuits, first with mechanical classifiers, and more recently with cyclones. Dry grinding in tumbling mills with air classification has also progressed, but only to a limited extent in concentrators.

Current trends indicate that autogenous grinding machines may gradually replace rod and ball mills. This is based on the following arguments. The rod or ball mill consumes power not because of its grinding service but because of its eccentric loading. It is well known that such a mill can consume as much or more power when free of ore as when actually grinding. It follows that grinding is accomplished by utilizing part of the kinetic energy of the tumbling load; in the absence of ore this energy is completely dissipated in a non-productive form. The proportion of energy consumed which is usefully recovered in the product remains undetermined for the lack of a measuring method and an adequate definition of grinding efficiency.

Such considerations were undoubtedly responsible for attempts over the past several decades to retain the tumbling mill principle and at the same time eliminate the grinding media. This should dissipate and utilize substantially all of the energy within the rock mass itself. These developments have taken two forms: 1) long-range autogenous crushing-grinding, typified by the Hardinge Hadsel, the Hardinge Cascade, and the Western Aerofall mills, in which coarse primary crushed rock is fed to a large-diameter short-length tumbling mill to obtain high reduction ratios, and 2) shorter-range autogenous grinding on finer feeds, in tumbling mill shells of conventional dimensions. The latter practice has become well established, particularly in Canadian and South African gold mills, and in Finland on a sulfide ore. Also from Finland comes the report that coarse rock may replace rods in the usual rod milling range.

Development of autogenous grinding is being actively pursued with at least a half-dozen mills in commercial operations. The essential feature is the use of mill diameters of 20 to 30 ft to impart enough kinetic energy to the falling rock for shattering. Either wet or dry systems appear possible. The dry mills may require drying the ore, if moisture is above 2 or 3 pct, and substantial fan installations for conveying and closed-circuit handling of product. The wet system is simpler in these respects; corrosion may be a problem but should not be more severe than with conventional tumbling mills. Both the Aerofall and Cascade systems have apparently overcome one of the difficulties with the original Hadsel mill, in that optional grinding ball loads can be used to prevent build-up of intermediate sizes.

The potential is growing for autogenous steel consumption. One of the African installations also reports substantially better metallurgical results. Overall investment could be less than with con-



This cut from AIME Transactions Vol. 41, 1911, shows an ore treatment landmark, the first continuous filter. The 50-ton Oliver filter was at famed North Star Mines in Grass Valley, Calif. A company article detailed operating results of first production Oliver unit at Tajo cyanide plant, Simaloa, Mexico.

ventional circuits where secondary crushing is eliminated. Fine autogenous grinding with screened ore is reported to save more money through elimination of ball consumption than is lost due to the effect of decreased capacity. This method appears to produce grinds with fineness comparable to that from ball milling.

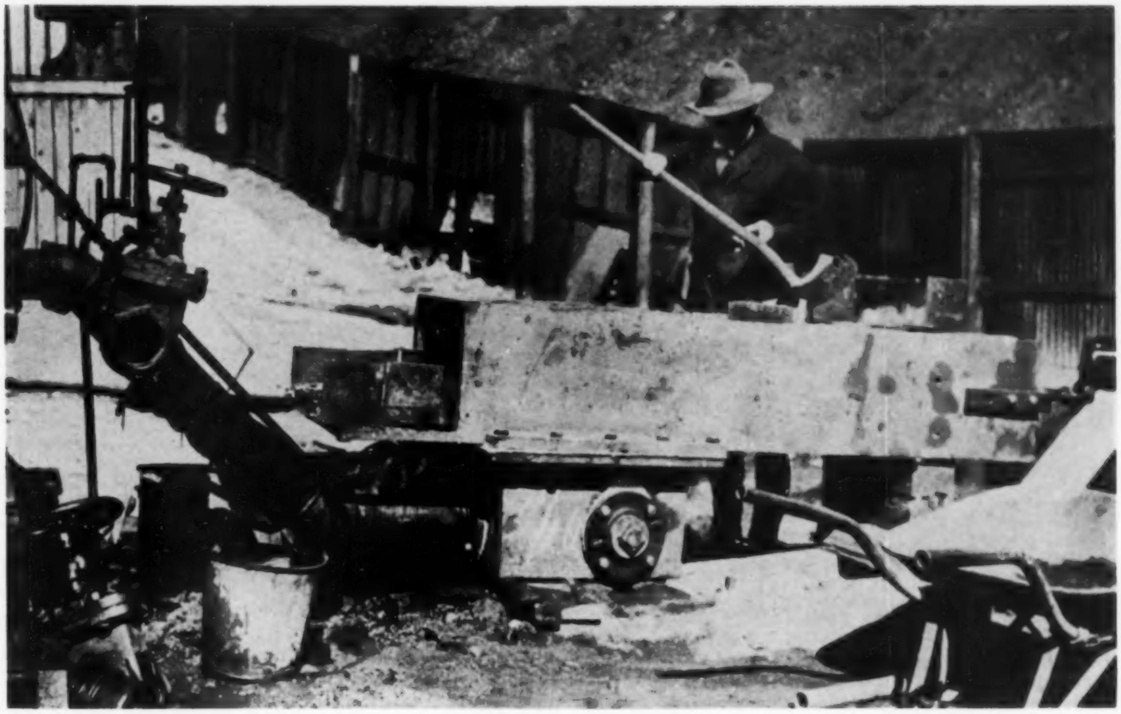
Thus, the overall general prospect is for autogenous size reduction from the 10 to 20-in. feed range (limited principally by feeding arrangements and possible mill diameters) to produce any desired finishing grind. The unanswered questions concern the feasibility of single-stage reduction in one mill of very large diameter, two-stage reduction with screened rock in the second stage, and the possible necessity of steel-grinding media in particular cases.

There are other developments in grinding that may conceivably modify the dominant trend toward autogenous breaking. Their common denominator is the application of higher speeds. This takes three forms: gyration or vibration of a shell containing grinding balls to produce a different type of ball action; the use of tumbling mills, with or without steel media, at super-critical speeds; and the use of high-velocity particle-gas suspensions in confined spaces to give ultrafine grinding. The first category is represented by Fahrenwald's gyratory ball mill, the Allis-Chalmers vibrating mill, and several Russian patents. All of these apparently obtain small-amplitude, high-velocity ball motion. This is claimed to give higher capacities, greater efficiencies, and smaller installation costs. There are not enough data available to support these claims on commercial scale.

Use of super-critical speeds with tumbling mills has been described by Tanner, Hukki and Heikkinen. For several decades it has been known that a ball or rod charge will centrifuge at a particular speed or slightly above it if the shell is provided with lifters and if the load level is about 40 pct. Power consumption under these conditions usually reaches a maximum well before the centrifuging speed. Hukki has found that with smooth liners, small mills can be run at speeds many times greater than critical and that the lower the load the greater the possible speed. The same effect can be obtained with rock charge. Tanner and Heikkinen describe the commercial operation of a rod mill at 104 pct of critical. An entirely different kind of ball or rod action is probable under these conditions. It is characterized by a greater degree of relative motion between the shell and the charge than at normal speeds. Observations in a 1-ft mill at Columbia indicate that the entire ball load is in active motion in contrast to normal-speed operations where about half the load moves with the shell. Although there are not enough operating data to permit conclusions, these studies are important in questioning the conventional approach to grinding.

The third category of innovations—grinding in high-velocity gas streams—has been under investigation for at least 20 years. It is being applied to softer materials of animal and vegetable origin and, to a limited extent, to ultrafine grinding of inorganics. Although this appears less susceptible to large-scale hard rock applications, it would be unwise to neglect this possibility.

In summary, this reviewer feels that a strong case is already being made to support the idea that rock can grind itself. It remains to be seen whether this



Arthur S. Dwight is shown charging copper sulfate fines into sintering machine in 1906. In 1958 successor firm celebrated 50th anniversary of date Dwight and partner R. S. Lloyd put first successful continuous sintering machine into operation in Salida County, Colo.

will develop with conventional mill shapes and speeds, altered designs and higher speeds, or entirely different methods of imparting higher velocity to the rock. In any event, the next few years in grinding should be exciting and promise little comfort for those tied to convention.

Concentration: Fifty years ago concentration was almost entirely by gravity methods. The jig, known in hand-operated and then in mechanized form for at least 2000 years, was still the mainstay of the mill. It was supplemented by a variety of moving and stationary film concentrators, the most important being the vanner. Amalgamation was in wide use, and the cyanide process, invented in 1890, was still in its infancy. Various forms of bumping tables were known but the Wilfley table, which combined the best features of the prior art, had just come into use. Richards felt it was here to stay, but was not quite sure of its full capabilities. Flotation was known in the patent literature, and the Elmore process was mentioned, but Richards was noncommittal about the future of flotation. Magnetic concentration of eastern iron ores was well established, and Thomas Edison had put up a 4000-ton mill in New Jersey embodying roll crushers and separators of his own design, as well as a briquetting process. Both expanding use of Mesabi high grade ores and the overestimation of reserves were to doom this venture.

In the intervening period, drastic changes have taken place. As already indicated, mill sizes have greatly increased. Gravity treatment of copper and zinc ores has been replaced almost completely by flotation, which is also of increasing importance for nonsulfide metallic ores and industrial minerals.

Gravity concentration of more coarsely disseminated ores is still important, but it has taken new forms. The heavy media processes adapted from the earlier Chance cone practice on coal now permit coarser separations than were possible with jigs. Although not yet widely used, the heavy media cyclone process extends absolute gravity separation down to 35 or 48 mesh. The jig is still in use, but in a narrower size range, and mainly for special applications. The shaking table has suffered a more drastic decline. Not only has flotation taken over fine sand concentration along with the subsieve sizes, but the spiral concentrator has directly challenged and largely replaced the table in the full range of sand sizes. Inspired by the potentialities for concentrating iron ore, rutile, and phosphate, among others, new types of gravity machines as well as improved electrostatic separation now appear to be encroaching on the spiral field.

Known in the eighteenth century and used commercially in this country well before 1900, magnetic separation is of growing importance in treating low grade magnetic iron ores. Prior to World War II this method was applied to the eastern magnetites and to a few other minerals for purposes of concentration, as well as to a variety of metallic and nonmetallic ores to remove iron-bearing impurities. The declines in reserves of domestic direct-shipping ores turned attention to the magnetic taconites in the 1940's and has now brought to fruition Edison's pioneering developments in New Jersey from 1890 to 1900 and the work of Jackling and Davis at Babbitt in the 1920's. The five to six millions tons of taconite concentrate produced in two Minnesota plants during 1958 is of the same order of magnitude as the total tonnage of copper concentrates produced in the country during the same period.

Current developments in magnetic separation in-

clude a renewed interest in dry machines—both to obtain more effective separation and to permit a complete dry flowsheet—and the use of very high intensities to permit treatment of the weakly magnetic iron oxides.

The growth of electrostatic concentration has followed a quite different course. Although the process has been known and machines have been available for many years, it has not been seriously considered for ore treatment until recently. Many laboratory separations have been demonstrated, and the process has been applied in the non-mineral field, but there have been only isolated attempts at commercial application on ores. The fairly high cost of equipment and the necessity for drying feeds and often for treating hot material have been regarded as prohibiting the process for all but high-value materials. Within the last decade, however, the situation appears to have changed radically. Intensive development work by equipment manufacturers, mining companies, and research organizations has led to actual applications for beach sand concentration and columbite-tantalite separation and to probable applications for pebble phosphate, potash, and feldspar.

Even more important, tonnage-wise, are recent impressive claims for the suitability of electrostatic methods in treating low grade iron ores. Information is being developed on preheating feed, handling fines, and designing equipment. While much more work will be needed before the full potential of electrostatic separation can be evaluated, it may eventually play an important part in dry-concentration of ores. In this field it should have the same versatility that flotation has in wet concentration.

The dominant importance of flotation treatment of copper, lead, and zinc ores has been mentioned. For sulfide ores in general the process has extremely high capabilities, limited principally by three factors: 1) degree of dissemination of sulfides so that either recovery or grade becomes limited by physical or economic limits of grinding, rather than by surface chemistry control; 2) insufficient understanding of the controlling physical factors in flotation of fine sizes; 3) insufficient understanding of the role of oxidation and its control. Where these factors are not important, very high levels of efficiency, recovery, and selectivity are possible.

In nonsulfide flotation the problems differ in degree and kind. The inherent selectivity that characterizes sulfide mineral collectors is not available, so that a greater complexity in reagent control usually obtains. Two additional problems appear to be general. Clays and other hydrous silicates, and the colloidal iron oxides, which are frequently associated, can preferentially adsorb collectors and other reagents. Desliming, with attendant loss of values, appears to be the sole available remedy to date. The other problem arises from the frequent necessity of high-intensity conditioning, which affects mineral surface chemistry in a way that is not understood. Despite these two problems, flotation is still the dominant concentration technique for the finer sizes.

Leaching: In addition to the development of new gravity methods, the displacement of old ones, and the swift rise in the importance of flotation, one other significant change has been in process—the increasing use of hydrometallurgy for metal recovery. At the turn of the century, the cyanide process was still in its infancy. It has since matured but more recently has declined in importance in the U. S. along with the general decline in gold milling. In Canada and South Africa it continues to be the major method for gold recovery.

Copper recovery by leaching was described by Swedenborg in the eighteenth century, when iron was first used to cement copper from mine water. U. S. application on a sizable scale became necessary for treating oxide cappings of porphyry coppers. There were similar developments in Chile and in Africa. Earlier plants were based on sulfuric-acid leaching of oxides and electrowinning. Later developments included leaching of mixed sulfide-oxide ores and of flotation concentrates and leaching with ammonia. More recent developments include large-scale cementation in place of electrowinning, leach-precipitation-flotation, and the commercial manufacture of sponge iron for cementation. Despite activity in flotation of oxidized copper minerals, leaching is still economically preferable except in rare cases.

Application of leaching to other metallic ores has expanded. From the start of aluminum production, leaching has been the only commercial process in the U. S. The process of roasting, leaching, and electrolysis for zinc concentrates was developed from 1920 to 1930 as a substitute for the retort process but did not replace concentration. Brine leaching of roasted lead concentrates has been tested commercially but has not been adopted.

Within the past 15 years, hydrometallurgy has been widely applied to nickel and cobalt ores. Recently low grade uranium ore, both here and abroad, has been treated almost exclusively by leaching.

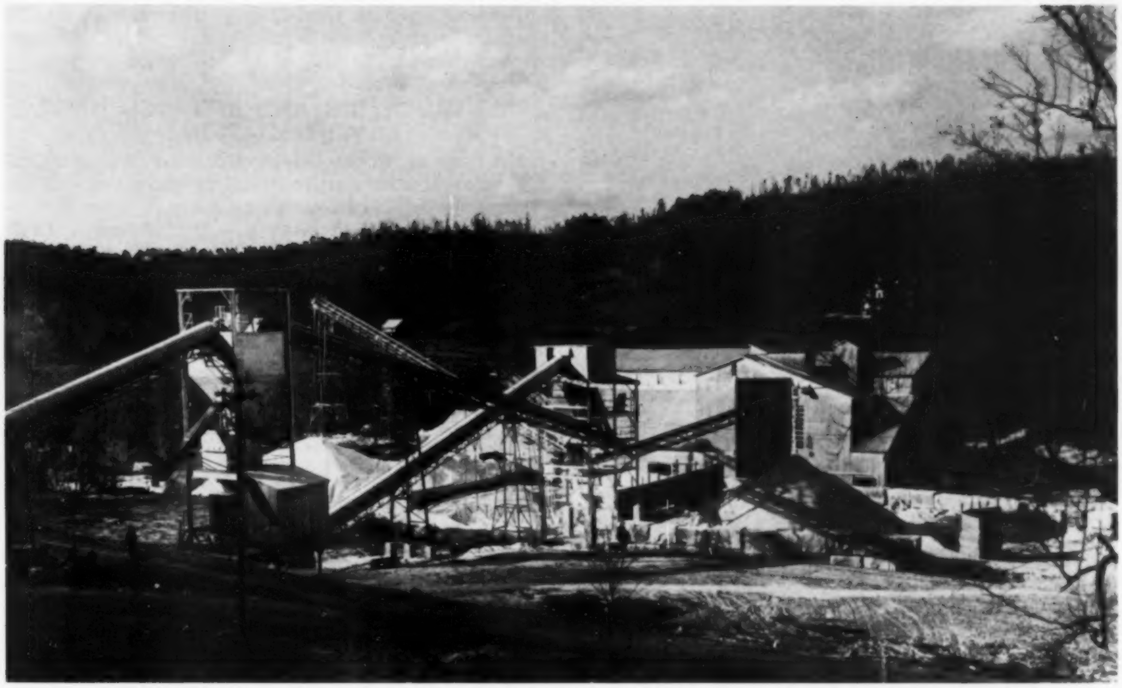
Precipitation of crude metals from leach solutions by cementation is the oldest method for metal recovery, and continues to be important. Electrowinning was developed later, first for copper ores and then for roasted zinc concentrates. Fused salt electrolysis, first applied to aluminum production and then to magnesium, is still in the developmental stage for metals such as titanium and zirconium.

Ion exchange and solvent extraction are the most recent innovations in removing metal salts and purifying leach solutions. At the present time these are mainly applied to high-value metals such as uranium and the rare earths, both to obtain concentrated solutions from dilute leach liquors and, simultaneously, to separate metal salts from soluble impurities. The resin-in-pulp or the solvent-in-pulp processes can additionally eliminate thickening and filtration.

TRENDS IN CONCENTRATION

Conservatism is doubly dangerous in estimating trends because in our expanding technology the odds favor change rather than the *status quo*. Failure to recognize merits of new processes can also retard progress. Change in itself is not necessarily a virtue, but it is usually stimulated by real necessities in the present scene.

In gravity separation, basic improvements in the heavy-media process in the coarse particle range do not appear likely. On the other hand, application of the cyclone heavy-media process to iron ore concentration will probably expand. The spiral is now taking over gravity separation in the sand sizes. One reason for this is that spirals make more economical use of floor space. It is tempting to suggest that employing much greater centrifugal force with the film concentrating principle could further reduce space



Plants such as this operation of Georgia Marble Co. illustrate gradual change in plant layout from slope-design gravity flow to more nearly horizontal designs with complex conveying systems. 1908 was the era of making machines continuous—1958 marks the era of making continuous operations automatic.

requirements. Actual developments in this direction are reported, and conceivably could extend the range of gravity separation to somewhat finer sizes than have heretofore been possible.

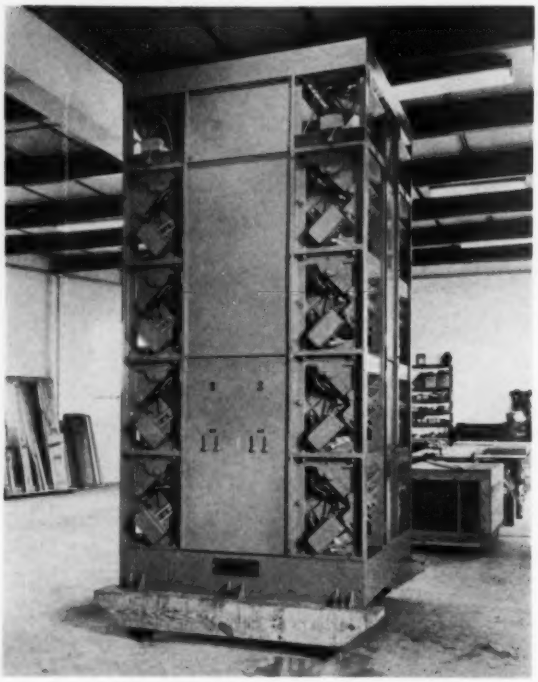
Treatment of more finely disseminated ores promises many new developments. In terms of tonnage, beneficiation of iron ores will soon become the most important field for concentration. In the more distant future, aluminum ores may also require beneficiation. But whereas physical concentration will probably always dominate beneficiation of iron ore, it is likely that for aluminum ores thermal treatment, followed by leaching, will be more important. For magnetic iron ores, magnetic concentration should continue to be the most important form of separation because it treats the whole size spectrum. The treatment of mixed magnetic and nonmagnetic ores, as well as completely nonmagnetic ores, should be a battleground involving high-intensity magnetic separation, electrostatic separation, and flotation. Flotation has an inherent disadvantage in its reagent requirements, which are likely always to exceed the power requirements for the electrical method. Both the electrical methods, on the other hand, require drying of feeds. The issue will probably be resolved in favor of the method that most effectively treats the finer sizes, and flotation may have an intrinsic advantage here. Another possibility is to use more than one method, applying each in its most effective size range.

Combined flotation-leaching of sulfide ores or mixed oxide-sulfide ores will increase. For very finely disseminated ores, bulk flotation followed by selective or bulk smelting is already under study. In the nonsulfide field, electrostatic separation promises to challenge flotation seriously unless more effort is directed to solving the slime problem in flotation. It is ironic that in the 50 years under review, our definition of slimes has merely been moved from 100μ to 10μ, the relative amounts in many cases being comparable. It is quite possible that future ore dressers will be concerned with slimes of the 1μ variety.

Milling Controls: Control in milling, in the broad sense, denotes any measures taken to insure maximum economic efficiency of processing. Such efficiency does not necessarily coincide with maximum technical efficiency. The attainment of maximum economy involves a balance between minimizing labor, material, and power consumption and maximizing concentrate grade and recovery. Labor economy depends on good machine and mill design and on judicious substitution of mechanical methods for labor in measuring and controlling process variables. Maximum metallurgical returns demand thorough knowledge of the relations between controllable process variables and yields.

Milling control 50 years ago was rudimentary. It was entirely visual and manual. Today we are rapidly approaching extensive automation. Crushing in well designed plants is already an exceptionally low-cost operation and need for extensive control development here is slight. But in grinding and concentrating circuits, substantial improvements in both labor requirements and metallurgical efficiency will result from stabilizing quality and quantity of pulp flow. Today, the main duty of the mill labor force is to measure and correct the effects of variations in grindability and to adjust concentrating circuits for variations in tonnage and quality. There are two ways to reduce this labor force: 1) eliminate the variables that make control necessary in the first place, or 2) make control and correction automatic.

The first alternative requires a naturally uniform orebody, a cooperative mining department, and plenty of money. Application of mixing and blend-



It is impossible to single out one device and say this was significant this year, but one guide is interest. Ten years ago the spotlight was on gravity devices. This year the Carpco high-intensity separator and other machines drew intense interest and marked a new surge for electrostatic and electromagnetic devices.

ing to make feed uniform will be slow in coming, particularly because it is impossible to measure the savings in advance and a large investment is required. But after a few installations have shown substantial savings this method of controlling ore variations will become general practice.

The second alternative, automation, is the more likely choice today. Lacking feed uniformity, the purpose of automation is to dampen circuit fluctuation by relatively instantaneous measurement of quantity and quality, and equally rapid corrective adjustment. Continuous weighing and adjustable feeding of dry solids and continuous metering of pulp flows are well known. Present automation of grinding circuits depends on these steps plus indirect measurement of grinding quality according to noise levels or classifier return loads. Still lacking is a device for continuous direct measurement of size distribution of the ground product. One possibility is to sample and cyclone the product and meter the flow and density of the cyclone discharges.

Continuous measurement of product tonnages is immediately possible in concentration circuits. Continuous assaying of products, once a faint hope, is now approaching realization. Descriptions of methods for continuous phosphate rock assay by the conventional wet method have been published. Continuous zinc tailing assay by x-ray fluorescence is in development. Continuous analysis of solutions is already used in production of antibiotics where analysis is coupled with automatic operation of ion exchange. Adaptation of this combination technique to leaching circuits requires only the demonstration of an advantage—and ingenuity. While the continuous sampling and assaying of ore solids is difficult in general, it has already been shown feasible. Its further development will await proof of the economic advantages.

EDUCATION AND RESEARCH IN BENEFICIATION

In contrast to the bright picture of technological progress, the domestic outlook in education and research is discouraging. Freshman engineering enrollment for September 1958 was 10 pct below 1957. But the percentage of those in the mineral industry field has shown either a static or a declining trend. No detailed figures are available on the number in mineral dressing because this is not an accredited undergraduate curriculum, and similarly, no figures are available for graduate students in this field, because it is not recognized as a major engineering subdivision. The numbers involved are small and, particularly in the graduate field, there is a large proportion of foreign students.

Furthermore, the situation during the past year was certainly not conducive to attracting students. Lay-offs were commonplace and these were not limited to the recently hired. In sharp contrast, job opportunities in the glamour fields such as rocketry and electronics are booming. These companies are hiring mineral engineering graduates at salaries far higher than any mining company would consider offering. The effect of these developments should be an increasingly short supply of engineers for operation and research in beneficiation.

There is an equally serious related problem. The amount of research activity in this field in the U. S. appears to be declining, both relative to that in other countries, and absolutely. For example, an overwhelming proportion of the publication on flotation during 1958 was from Soviet sources, contrasted to small number of American papers. The poverty of U. S. publications reflects a serious situation in research itself.

At present a limited number of mining companies and equipment manufacturers occasionally contribute funds for pure research to the mining schools. There is little or no such research carried out by the industry itself. The Federal Government has in the past supported research in our field in a limited way but the scale of this support has apparently been reduced. Activities of the Bureau of Mines in beneficiation appears to have been limited to ore testing in recent years. Thus, research is limited, and carried on by a few mining schools, supported either by their own budgets or by occasional contributions from industry or government. In contrast, the trend abroad in non-communist countries is toward modest but growing support of beneficiation research by both government and industry, while governments in the communist bloc are providing massive support.

The fruits of this neglect will not be felt immediately. We in the U. S. are doing significant bread and butter development work, which will maintain an improved efficiency of operation and contribute to progress. But loss of leadership in the research field and in the probably diminishing supply of beneficiation engineers can have serious effects in the economic and political struggles which face us. No easy remedy is proposed, but it is urged that this problem requires very serious consideration by both the Society of Mining Engineers and the Institute.

REFERENCE

[1] A. S. Taggart: *Handbook of Ore Dressing.*

URANIUM PROCESSING PLANTS

	Company	Location of Mill	First Contract Signed	First U_3O_8 Delivered to AEC	Present Contract Terminates	Rated Capacity Tons of Ore Per Day	Estimated Cost of Mill
1.	Anaconda Company	Grants, N. Mex.	Dec. 27, 1951	Sept. 1953	Mar. 31, 1962	3,500	$19,358,000
2.	Climax Uranium Company	Grand Junction, Colo.	July 10, 1950	June 1951	July 31, 1960	330	3,088,000
3.	Dawn Mining Company	Ford, Wash.	Aug. 8, 1956	Sept. 1957	Mar. 31, 1962	400	3,100,000
4.	Freemont Minerals Inc.	Riverton, Wyo.	Dec. 4, 1957	Jan. 1958	Nov. 30, 1963	500	3,500,000
5.	Government-owned	Monticello, Utah	—	Jan. 1950	—	350	5,000,000
6.	Gunnison Mining Company	Gunnison, Colo.	Nov. 15, 1956	Feb. 1958	Mar. 31, 1962	200	2,025,000
7.	Homestake-New Mexico Partners	Grants, N. Mex.	Dec. 20, 1956	Apr. 1958	Mar. 31, 1962	750	5,325,000
8.	Homestake-Sapin Partners	Grants, N. Mex.	Apr. 23, 1957	Sept. 1958	June 30, 1963	1,500	9,000,000
9.	Kermac Nuclear Fuels Corp.	Grants, N. Mex.	May 3, 1957	Dec. 1958	Dec. 31, 1966	3,300	16,000,000
10.	Kerr-McGee Oil Industries	Shiprock, N. Mex.	Aug. 17, 1953	Jan. 1955	Oct. 31, 1959	300	3,161,000
11.	Lakeview Mining Company	Lakeview, Ore.	Nov. 18, 1957	—	Nov. 30, 1963	210	2,600,000
12.	Lucky Mc Uranium Corp.	Fremont County, Wyo.	Nov. 14, 1956	Mar. 1958	Mar. 31, 1962	750	6,900,000
13.	Mines Development Inc.	Edgemont, S. Dak.	Apr. 28, 1955	Aug. 1956	Mar. 31, 1962	400	1,900,000
14.	Phillips Petroleum Company	Grants, N. Mex.	Sept. 17, 1957	Aug. 1958	Dec. 31, 1966	1,725	9,500,000
15.	Rare Metals Corp. of America	Tuba City, Ariz.	July 15, 1955	July 1956	Mar. 31, 1962	300	3,600,000
16.	Texas-Zinc Minerals Corp.	Mexican Hat, Utah	July 17, 1956	Nov. 1957	Dec. 31, 1966	1,000	7,000,000
17.	Trace Elements Company	Maybell, Colo.	Aug. 10, 1955	Dec. 1957	Mar. 31, 1962	300	2,208,000
18.	Union Carbide Nuclear Company	Rifle, Colo.*	Oct. 2, 1947	Dec. 1947	Mar. 31, 1962	1,000	8,500,000
19.	Union Carbide Nuclear Company	Uravan, Colo.	Apr. 13, 1949	Mar. 1950	Mar. 31, 1962	1,000	5,000,000
20.	Uranium Reduction Company	Moab, Utah	June 1, 1955	Nov. 1956	Mar. 31, 1962	1,500	8,250,000
21.	Vanadium Corp. of America	Durango, Colo.	Feb. 17, 1949	Aug. 1949	Mar. 31, 1962	750	813,000
22.	Vitro Uranium Company	Salt Lake City, Utah	Oct. 25, 1951	Oct. 1951	Mar. 31, 1962	600	5,500,000
23.	Western Nuclear Corp.	Split Rock, Wyo.	Aug. 10, 1956	Aug. 1957	Mar. 31, 1962	400	3,600,000
					TOTALS	21,065	$134,928,000

* Union Carbide Nuclear Company also buys ore at Slick Rock, Colorado, and Greenriver, Utah, as feed for the Rifle, Colorado, mill.

NOTE: Except for the Government-owned mill at Monticello, Utah, the above mills are privately owned and operated, and all are licensed to buy uranium ores from producers. The USAEC buys the concentrate product under the terms of contracts with each mill operator.

(Prepared by Information Division, GJOO)

OPEN PIT MINING CONCENTRATES ON BLASTING

The impact of research and the fast moving developments marked 1958 as the year the industry continued to progress in haulage techniques—but really studied its blasting.

The pattern of holes, how they are to be drilled, what goes into them, and how they produce broken rock has been the subject of intense, cost-cutting study and considerable basic research.

The year was marked by introduction of down-the-hole drills big enough to give rotarys a run for their money, by closer study of the proper role for the rotary, and by testing of lighter and more mobile mounted drill rigs.

AN continued to attract study on a cost basis. More promising in the long run, however, has been the concentration on the basic mechanics of blasting. The year was marked by the largest blast ever, by atomic explosions underground, by the great progress made at Reserve in effective breaking of tough and uniquely fractured material.

The "breakthrough in research" has come with a bang—and attention to, and attendance at, research symposiums is the best assurance that this interest will be maintained and backed up with dollars.

Loaders have grown larger, tougher, and find increasing roles in pit operations as well as in general material movement.

Three important recent developments are demonstrated here, two apparent, one hidden. Pushers, graders, rippers, and auxiliaries step up earthmoving effectiveness. Skip hoisting permits tailoring pit profile to deposit, not haulage, needs. Not visible—torque converter drive for smoother, more effective operation.

DRILLING AND BLASTING SYMPOSIUM BRINGS VIEWS ON RESEARCH AND PRACTICE TOGETHER

The eighth annual Drilling and Blasting Symposium, presented by the University of Minnesota's School of Mines and Metallurgy and Center for Continuation Study, was held on the University campus October 2-4, 1958. Sponsored by the University of Minnesota, Colorado School of Mines, and Pennsylvania State University, the three-day meeting was attended by representatives of industry from Europe, Canada, Mexico, and the U. S. Sessions covered production drilling, progress in manufacture and use of drill steels, present practice in blasting, and advances in laboratory research. The final session on October 4 was introduced by a review of new ideas and techniques, followed by a five-man panel discussion.

Opening contributor to the program on production drilling was H. E. Hertzog, superintendent at Peabody Coal Co., who analyzed deciding factors in the choice between vertical and horizontal drillholes in strip mining. Among these factors are: 1) yardage per pound of exposives, 2) height of overburden, 3) capacities of various drills, 4) preparation of material for drilling, and 5) problems of keeping explosives at drilling areas under difficult weather conditions. Adolph Soderberg, consulting engineer for Kennecott Copper Co., described the mechanical advances his company has made in using the rotary air drill for blasthole drilling; water injected into the air stream eliminated the use of dust collectors, which had been a constant source of difficulty. He also outlined the procedure for loading ammonium nitrate into nearly horizontal holes with a pneumatic loader. Robert T. Macaul, director of Drillmaster sales at Ingersoll Rand in New York, stressed three advantages of downhole drilling: 1) no energy losses in the transmitting drill rods; 2) independent rotation, which can resist all but the most impossible drag conditions; and 3) more uniform holes, even under the most severe conditions of rock structure.

For several years there has been a trend toward smaller diameter drill rods. Combined with the greater number of drill blows per minute this offers increased efficiency, but at the cost of more rod breakage. At American Metal Climax, says Max Ahrens, new testing procedures have done much to solve the breakage problem.

Recent years have brought real improvements in manufacture of hollow drill steel, particularly since the introduction of tungsten carbide bits. Notable among these advances, says H. T. Cromie of Crucible Steel, is the development of new types of drill steel with greater resistance to breakage.

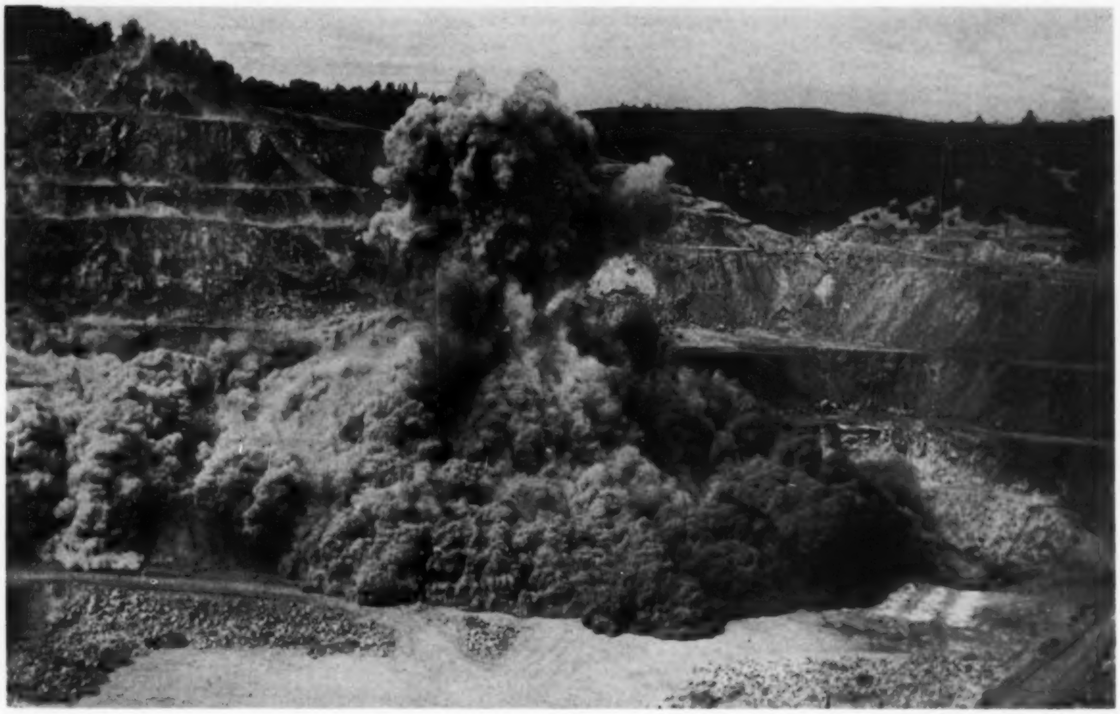
Guest Lecture at the session on drill steels was prepared by Karl-Heinz Fraenkel, director of engineering of the Royal Water Board in Stockholm and editor-in-chief of the *Manual of Rock Blasting*. Erik Ryd, deputy managing director of Atlas Copco AB in Stockholm, presented the lecture, which dealt with economic influences—and the degree of mechanization desirable—in planning rock excavations. The paper gave comparative tunneling costs in European countries and evaluated methods of driving large tunnels up to 4000 sq ft.

Next day the session on blasting was opened by a talk on new developments in using ammonium nitrate, given by Dort F. Tikker, manager of industrial technical service at Monsanto Chemical Co., St. Louis. The presentation covered such factors as stoichiometric balance of fuels, density of explosives under different conditions, and varying confinements.

The versatility of ammonium nitrate has been extended by a new and inexpensive blasting agent, a water-compatible mixture of ammonium nitrate and TNT invented by M. A. Cook of the University of Utah and H. E. Farnum, Jr., manager of operations at the Iron Ore Co. of Canada, Sept-Iles, Que. This explosive slurry, as described in Farnum's paper, was designed primarily for use in wet holes and was not intended to replace the mixture of AN and fuel oil now in general use. The fluid mixture can be loaded easily in bags or directly into boreholes without a container. Its strength is comparable to that of 70 pct gelatin dynamite, but its sensitivity is much lower and requires a high explosive primer, preferably a 6-oz pellet of Pentolite, set off by electric blasting cap or Primacord detonating fuse. So far this new explosive has achieved good fragmentation under hard breaking conditions, but a number of handling problems must be solved before it can be widely used.

Following a recess, the session on blasting was resumed with a paper by DuPont's technical representative, E. M. Fowler, who developed the historical background in using millisecond delays. Early technique was known as *fast* delay blasting and was directed along the lines of breaking up large single blasts fired more or less instantaneously into a series of smaller blasts fired with short intervals of time between. Since that time, techniques have advanced so that millisecond delay blasting can be applied to almost all open pit work, although certain hazards must be avoided. Millisecond delay blasting was also applicable in underground operations, but could not be properly evaluated because not enough periods were available. When periods were eventually made available for short trials at an underground mine heading on the Menominee Range, the experiments substantiated some theories on the short time intervals needed to break successfully to bottom 10-ft rounds in dense material. Work on the Gogebic Range threw light on the possibilities of dependably pulling 12 to 13-ft rounds in slaty material bedded parallel to the axis of a small heading using a five-hole burn cut. Further work continues in various areas on the general application of millisecond delay blasting to heading work, while at the moment advantages of this type of shooting in certain kinds of stoping appear to be well recognized. Advantages and disadvantages must fit the local economic picture.

Gordon E. Frantti of the USBM showed some excellent high-speed photographs of production blasts in taconite and limestone. These films provided a fine visual explanation of many of the characteristics of a blast, and many viewers requested a second showing.



Practical application and theoretical development of AN explosives continued at peak during 1958. This quarry blast-demonstration by Spencer Chemical in California demonstrates scale of usage reached in short span of years.

Basic Research Applied to Practical Blasting: Initial rock fracturing by explosives is caused by the reflected seismic wave. An evaluation of the seismic wave will indicate the blasting efficiency of the seismic-wave source. In an experiment reported by Arthur Ruff, assistant mine superintendent at Cananea Copper in Mexico, strain gages were installed in drillholes, and the seismic pulses were recorded as oscillograms when charges of different types of powder were detonated. The oscillograms were evaluated to determine the type of powder best suited for blasting the rocks where the tests were performed. The results of these tests showed that present millisecond delay caps can not obtain better fragmentation by producing seismic-wave interference.

A study by John Cheathem, of Shell Oil's research division in Houston, concerned the influence of rock as a function of the angle of internal friction and unconfined compressive strength of the rock. A paper on energy transfer in percussion drilling, by Charles Fairhurst of Minnesota's School of Mines and Metallurgy, dealt with the procedures and some of the results of current research at the University. Preliminary findings of stress-wave transmission along drill steels indicated close agreement between theory and actual observations. The influence of drill piston mass and impact velocity on the strain wave-form was discussed.

In the closing session of the Symposium, operational experiences were pooled in a five-man panel discussion. Robert Akre of Maumee Collieries in Terre Haute, Ind., stated that in his experience most overburden conditions are well adapted to the use of ammonium nitrate blasting agents if careful attention is paid to proper hole size, burdens and spacing, etc., to utilize the available energy. Where shooting is hard and good breakage essential, overall costs may show that lower-cost blasting agents are not the most economical. Up to now, the major limitation of AN has been its water resistance. But the high-speed detonation of new slurry-type blasting agents, said Kenneth Ed, of Canadian Institute Ltd., have made increased burdens possible. At present these water-compatible agents are about 1.7 times more expensive than packaged AN prills.

A paper by A. F. Johnson, chairman of the board of Al Johnson Construction Co., described marine rock dredging in the upbound channel of the Detroit River. This operation employed an ingenious drilling barge mounting 20 drills and a 7-yd dragline to excavate broken rock.

Some economic studies on use of the jackleg drill, presented by Erik Ryd, indicated the following cost distributions: labor, 50 pct; drill steel, 30 pct; compressed air, 5 pct; and miscellaneous, 15 pct. These figures showed the importance of ease of moving and fast drilling as compared to drill efficiency—at least from the standpoint of air consumption.

In a final summary of drilling and blasting practice on the Mesabi Iron Range, Alfred Savage, superintendent of Oliver Mining's Plummer mine, said that even in taconite areas 25 pct by weight of ammonium nitrate prills in the charge has produced good fragmentation, and operators in these areas have found the low cost of ammonium nitrate explosives attractive.

Within the last year, changes in drilling have been significant. Rotary drilling has shown marked improvement, and some operators have estimated rotary penetration at three to six times that of churn drills. Today's operators are wondering how far the downhole tools will go to supplant rotary drilling and jet piercing.

MISSOURI SYMPOSIUM DISCUSSES AMMONIUM NITRATE

Attention was focused on blasting with ammonium nitrate explosives, particularly their fundamental performance parameters, at the Fourth Annual Symposium on Mining Research at the Missouri School of Mines on November 13-15, 1958. One of the aims of the conference was to bring to the attention of mine operators the usefulness of mathematics and calculation in getting answers to explosives problems.

The welcoming address was given by Dr. A. L. Schlecten, Chairman of the Department of Metallurgical Engineering, MSM, who noted that it was a healthy trend when a program in one of the mineral industries could show so many physicists and chemists contributing their knowledge to mining. Such overlapping of interests, particularly from the fields of basic science, are important to significant progress.

SESSION HIGHLIGHTS IN BRIEF

• The Promontory Point blasts were illustrated by a moving picture of the first blast of 1.7 million lb which broke approximately 3 million tons of rock. Two larger blasts have been detonated since the moving picture was made. In each case the blasting agent was 80 pct Amocol, a bag-packed, nitrocarbonate blasting agent and 20 pct of a 60-pct dynamite.

• The Ripple Rock Blast, which removed a dangerous obstacle in the Seymour Narrows in the Inside Passage to Alaska, is the largest non-atomic blast in history to date. Two subsurface pinnacles were blasted by sinking a shaft on shore and driving tunnels underneath them. Planning operations included model studies of both breakage and dispersion of rock which was to provide a clearance of a minimum of 40 feet at low tide. A heavy density explosive, Nitramex, was employed for blasting.

• Underground nuclear blasts have occupied the interest of mining men since the first shot was made over a year ago. In the first blast the fuzed glass around ground zero seemed effective in containing the radiation.

• Mathematics of high explosives calculations may be very complicated for some explosives. For most oxygen balanced explosives computations are relatively simple. In more complex cases, however, the solution of problems involves hydrodynamic, thermodynamic, chemical equilibria, heat balance and material balance equations. To solve for such parameters as detonation velocity, pressure and temperature may involve the solution of twenty or more simultaneous non-linear algebraic equations. Problems are suited for solution on digital and some types of analog computers.

• The determination of the equilibrium composition of gaseous reaction products arising from the explosion of a condensed moderately oxygen negative CHNO explosive is generally a tedious and time consuming chore. Since usually nine or more products are considered to interact near the temperature of explosion, a system of as many non-linear simultaneous mass-action equations needs to be solved (along with four linear material balance equations) for each of a set of initially assumed temperatures. Moreover, the isochoric heat of explosion which determines the temperature of explosion on an energy vs. temperature curve must often be recalculated to conform with product compositions.

Experimental data have been obtained on the spherical propagation of explosion generated strain pulses in five different rock types employing 10 different types of explosives. Charge sizes varied from 0.5 to 50 lb and gage to shot point distances varied from 2.5 to 70 ft.

Analysis of the strain data from all tests shows that the peak value of the strain pulse satisfies an exponential decay propagation law of the type

$$R/W^{1/3} = \epsilon K e^{-R/W^{1/3}}$$

where ϵ is peak strain, R is gage to shot point distance, W is charge weight, K and α are parameters, and e is base of natural logarithms.

Detonation properties of the explosives were calculated by a method suggested by Brown. Correlation studies between the parameters in the propagation equation and the calculated detonation properties of the explosives and the elastic constant of the rock gave the following results:

1) For a given rock type, the parameter K correlates linear with either the calculated detonation pressure or the calculated energy per unit volume of the explosives with K, increasing as the pressure or energy increased.

2) For a given explosive, the parameter K correlates linear with the elastic constant, pc^2, of the rock, with K decreasing as pc^2 increases.

3) The absorption constant α is independent of explosive types but dependent on rock type. However no definite correlation between α and the physical properties of the rock could be established.

A detailed description of the test procedure, method of data analysis, experimental data, and results will be found in a forthcoming Bureau of Mines Report of Investigations, *Spherical Propagation of Explosion Generated Strain Pulses* by Wilbur I. Duvall and Benjamin Petkof.

• The properties of a novel series of slurry explosives and methods for evaluating explosives of this general type described by M. A. Cook. The slurries are compared by these methods with the popular "94/6" "guhr" coated, prilled ammonium nitrate-fuel oil explosives used in this study as the standard for camparisons. The preferred TNT in the slurry explosives is a coarse, "shot tower" product currently sold in America under the name Pelletol and in Canada as Nitropel. This product is not cap sensitive by itself and is much safer than "flaked" or fine grained TNT. It therefore lends itself well to do-it-yourself operations with the slurry explosives. Heavy, 400 grain per ft primacord initiation of slurry explosives and the AN-fuel oil mixtures is described and shown to be an inferior type of initiation that does not produce detonation in the standard AN-fuel oil mixture, but only explosive deflagration. Moreover, it does not detonate in single strand quantities any but the more sensitive slurry mixtures containing at least 40 pct coarse TNT.

• Certain aqueous ammonium nitrate slurries sensitized with TNT are higher strength explosives than the dry mixtures. The basic slurries are not ideal for use in commercial blasting operations because of a tendency for the ingredients to segregate during handling. Experimental work is described whereby the physical properties were modified to control segregation, provide good flow characteristics, and enhance water tolerance. Several techniques are described which are appropriate for the manufacture and shipment of slurry explosives as a packaged product and for on-site preparation for immediate use.

• Iron Ore Co. of Canada has been gradually converting and now are using about 80 pct do-it-yourself type mixes to save money. Certain situations required the use of more powerful water compatible explosives and slurries of AN-TNT met this need. A cheaper booster of 165 g of cast pentolite is employed to initiate detonation. Hole spacing of 15x15 for fuel mixtures was increased to 21x23 for 10-in. diam holes with good results in 40-ft holes. Recent tests have given successful results with 6½-in. diam holes in a 16x16 spacing. Diameter must be balanced against spacing in order to bring the explosive sufficiently high in the holes.

Costs for material only were found to be 4.5¢ per lb for AN and fuel and 7.75¢ per lb for slurries. However, on a basis of cost per ton of broken rock the cost of the slurry proved to be much less than the AN fuel oil mixes.

• Blast damage due to shock waves in air is due mainly to the peak pressure and positive impulse of the wave. Due to dissociation of air and rapid energy dissipation at the blast front the classical theory cannot be applied. An analysis of a one-dimensional wave, following the work of Kirkwood and Brinkley, permits the prediction of blast parameters such as peak pressure, specific energy and positive impulse. The theory is based on two basic hydrodynamic equations and boundary conditions at the front of a shock wave.

• Statistical mathematics may be applied with advantage to analysis of results of explosives testing. Where "yes or no" answers are involved an "up and down" type of plot yields a more exact answer as to explosive sensitivity, for example.

• Tests of fumes given off from the explosion of AN fuel oil mixes showed that in certain cases significant amounts of noxious oxides of nitrogen were produced. Careful consideration should be given this fact before such mixes are used underground.

Extensive experimentation with ammonium nitrate explosives was reported on by the explosives research group of the Missouri School of Mines. The types of various fuel additives, percent fuel oil, particle size, charge diameter, percent inert coatings were found to affect explosive performance. Oxygen balanced explosives are best for most combustions. A small amount of inert coating increased detonation velocity for fuel oil mixtures, decrease in particle size resulted in increased velocity, whereas mixtures of particle sizes gave variable results. Detonation velocity generally increases with density and charge diameter. As far as investigations have gone number two fuel oil appears to be the best fuel for shooting in dry holes.

A comparison of detonation velocity measured in blast holes in strip mines was found to correlate closely with results of detonating the same mixture in 3-in. pipe. Standard pipe appears to provide sufficient confinement for most test purposes.

Over the years ammonium nitrate has become the most important ingredient of blasting explosives culminating in its use in mixtures of prills and fuel oil. Previous information indicating maximum detonation rates in ammonium nitrate mixture containing 5 to 6 pct fuel oil have been confirmed. Comparative work on the results obtained with dynamite grades of ammonium nitrate made by a crystallizing process have indicated a substantially higher detonation rate for this type of material which can be coupled with higher densities of loading and a higher degree of reliability in propagation. Prepackaged mixtures of ammonium nitrate blasting agents such as the Hercules Dynatex grades have shown excellent performance in quarrying and open pit operations. Their use permits increasing the spacings between holes and very substantial reductions in the overall costs of blasting as compared to prill fuel oil mixtures. Furthermore, the dynatex blasting agents can be furnished in highly water resistant types for general application in packages. Optimum results with dynatex blasting agents are obtained when the powder is poured in the hole to give maximum loading density and consequently maximum borehole pressure.

UNDERGROUND MINING AND FASTER SHAFT SINKING

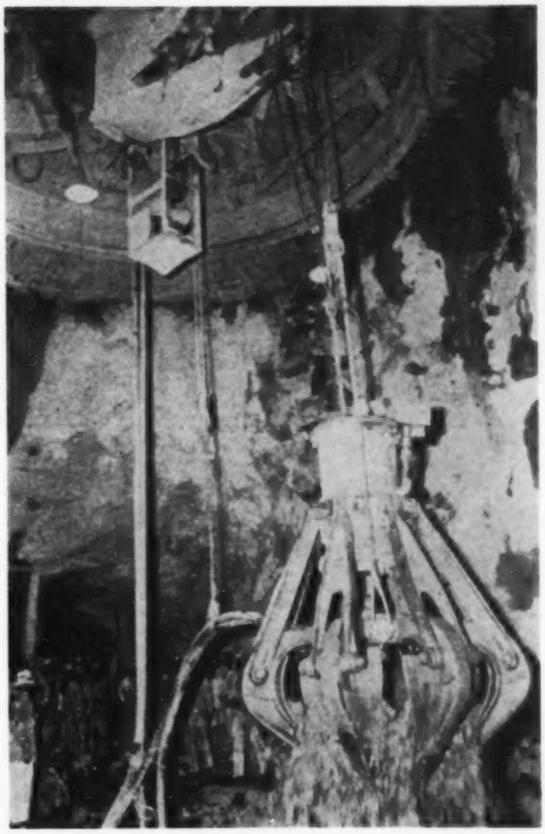
Highlight of the year was the speedup in sinking smaller shafts—better tools and techniques for raises and winzes, more knowledge of shaft freezing for major operations, records for depth and distance both here and in South Africa.

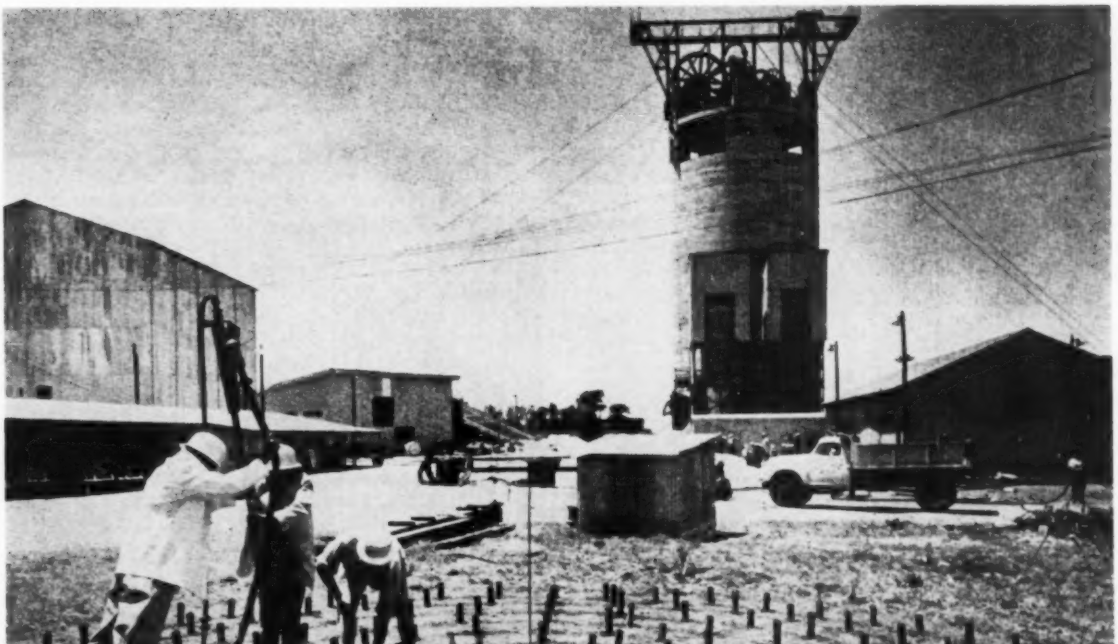
If you must sink a 30-ft diam shaft fast, it is costly, but possible. Mechanizing a much smaller one is another story. On the Plateau, at Blind River, and elsewhere, the speed of sinking has accelerated as shaft mucking devices have been invented and improved—and operators have learned how to use them. You can even rent the smaller ones today.

Cryderman solved the mucking problem for the smaller as well as larger inclined shafts. One lawsuit (another machine) proved the inventor has a right to a profit from his ideas, and great ingenuity was displayed in sinking winzes and pushing raises.

SOUTH AFRICA CONTINUES TO LEAD IN SHAFT SINKING

Setting records for both speed and depth, the great gold mines of South Africa continue to lead the world in shaft sinking. Large diameters, up to 30 ft, permitted large crews of muckers and without any mechanization of this operation fast rates were achieved. As depths increase and costs rise, improvements become necessary and the photo at right shows a grab being used for muck removal. At bottom is a view of a standard round of 192 holes used in sinking a 24-ft diam circular shaft. Current record achieved in the Orange Free State is 834 ft per month—deepest is now the Hercules section of the East Rand Prop. Ltd., where a pilot winze is just below 11,000 ft vertical depth.





FASTER SHAFT SINKING WITH NEW JUMBO, SAFETY SKIP

Using a specially-equipped umbrella-type shaft jumbo and a recently-developed skip, Shattuck Denn crews recently made 392 ft in 25 days for a daily average of 15.7 ft. Water swamped the possibility of running up a new shaft record for a single month but the new equipment promises high scores for the future.

Shattuck Denn Co.'s Bardon shaft located in the Big Indian District, 50 miles southwest of Moab Utah, was drilled last fall to reach a uranium orebody at a depth of 830 ft.

The two-compartment, 14x7-ft shaft was collared to a depth of 110 ft before sinking got under way in mid-September. It took several days to acquaint the newly-hired crew with the new shaft equipment and overcome resistance to the new ideas. Despite this slow start, 392 ft of completed shaft was made from September 15 to October 10, for a total shaft depth of 502 ft and a daily average advance of 15.7 ft. At 502 ft heavy bentonite ground of the Chinle formation slowed the drilling operation and the shaft continued in this ground to bottom at 830 ft.

The mine surface plant consists of a 200-hp Vulcan single-drum hoist with a rope speed of 650 fpm and a ⅞-in. sinking cable. Two compressors supply 1200 cu ft of air at 110 psi. The 54-ft steel headframe has dumping scrolls mounted 10 ft above the shaft collar so that shaft muck can be handled by bulldozer, truck, or double drum slusher. With this setup there are no delays from handling shaft muck.

The shaft site and surface area are in hard bedrock and this added to the problem of keeping 4500 ft of surface water lines from freezing at an elevation of 7000 ft, where winter temperatures are subzero. Confronted with the slow, costly job of placing these lines 4 ft underground, T. W. Newill, Shattuck's vice president and general manager, devised a method of keeping all surface lines heated by electric current. Water temperature in the lines was controlled by a thermostat which maintained a constant 40°F.

Geology of the area showed the Kayenta formation lay from surface to a depth of 90 ft. From here to 430 ft the formation is Wingate sandstone, with 25 gpm of water at a depth of 400 ft. The Chinle formation at 430 ft continues to a depth of 810 ft, where the Shinarump formation occurs to 830 ft.

Before sinking the Bardon shaft, Shattuck Denn's management felt that improving their methods would produce a faster sinking rate at lower cost. Collaboration with Shaft and Development Machines Inc. and Machinery Center Inc. of Salt Lake City, produced a compact jackleg drill jumbo and safety sinking skip and led to introduction of a fan mounted in the cage of the Cryderman shaft mucker. Results proved all the innovations worthwhile.

Jackleg Drill Jumbo: In open circular shafts, drill jumbos have been successfully used, but in rectangular shafts, because of limited compartment size, it has been a problem to devise a quickly set up jumbo that could outperform conventional jackhammer drills.

The new jackleg jumbo, supporting four Atlas Copco Tiger drills with retractable legs, is a compact unit. When collapsed, it will pass through a 48-in. opening, yet can be easily and quickly set up for drilling. Operating like the spokes in an umbrella, the two ribs are raised by a chain hoist which brings the supporting sections up horizontal. From the top of these sections, two air cylinders extend 30-in. piston rods which are anchored into each side of the shaft. The unit is handled in the shaft by a cable attached to the bottom of the sinking skip. Setup time, from surface to a depth of 450 ft totaled 8 min.

The leader of the three-man shaft crew operates two drills, while the other two men handle a drill each. In the Bardon shaft 36-hole, 6-ft end cut rounds were drilled. The horizontal arm supporting the drills has two fixed positions. These give the machines great flexibility for movement anywhere in the shaft. Drills are suspended from the horizontal section of the jumbo, making it easy to drill horizontal holes for bearing sets.

In the Wingate and Chinle formations, 1-in. hexagonal steel with integral chisel bits gave fast penetration and the retractable leg's 300-lb pull eliminated miner fatigue usually caused by drawing drill rods from the holes by hand.

On completion of a round, the jumbo was dropped into the collapsed position and easily hoisted to surface. Over-all drill time from the time the unit left the surface until it was returned was 1 hr.

Electric caps with 10 m-sec delays were used with 24x1¼-in. gelatin powder. The primer cartridge

with an additional stick was loaded in each hole. Two buss wires shaped in a U were anchored in the shaft bottom for parallel firing.

In practice, after loading the round in about a half hour, the crew coming up the shaft starts the fan mounted on the deck of the Cryderman cage, then goes to the surface and fires the round. Five minutes after the blast the men return to the bottom and resume the sinking cycle. This is possible only through use of an efficient ventilation system.

Ventilation: A 4500-cfm Axi-vane fan is mounted on the top deck of the Cryderman shaft mucker, with metal vent tube extending through the cage to the operator's deck. The Cryderman machine is generally raised 40 ft above the bottom for blasting, so a great air turbulence is created by the fan in the shaft bottom. A 7500-cfm fan mounted on surface at the Bardon shaft has an 18-in. vent tube extending down the shaft, below the blowing fan on the Cryderman cage. Recirculation was avoided by keeping the 18-in. vent tube of the drawing fan below the blowing fan on the Cryderman cage. A 10-ft upright vent pipe was placed on the exhaust end of the surface fan to keep exhaust smoke from being drawn into the open shaft. By observing the discharge end of this upright pipe, the miners could tell when the shaft was cleared of smoke. The interval, or smoke time, was not more than 5 min.

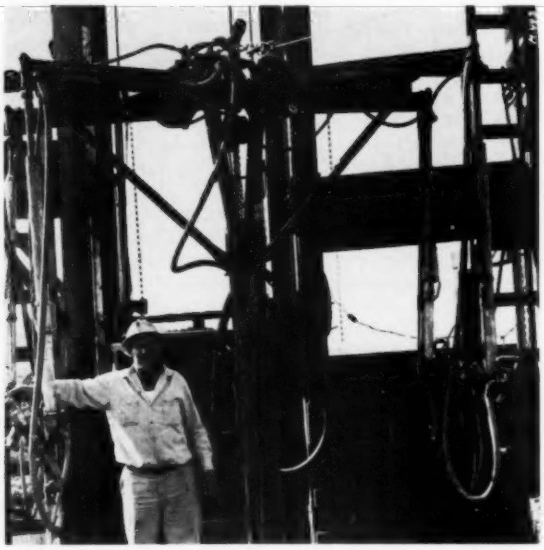
Safety Sinking Skip: Loss of time dumping the conventional round sinking skip with ball and chain was the reason for developing a square, 70-cu ft skip. Its shape gives greater area in the 5-ft compartment and its action on surface is like the conventional production skip in that there is no surface delay as the skip goes into the dumping scrolls, discharges its load, and quickly returns to the shaft bottom.

The main hoisting cable is attached to a bridle from which two 30-ft ¾-in. cables are suspended. These cables pass through the standard crosshead and onto the sides of the sinking skip below the crosshead. On reaching the chairs at the lowest set of timber, the locking lugs holding the torpedoes are opened by the chairs, permitting the torpedoes and skip to pass to the shaft bottom. As the loaded skip leaves the bottom the torpedoes pass the locking lugs and release the crosshead for movement up the shaft. The locking lugs fall into position, locking the crosshead and skip together for movement in the shaft. An important safety feature, the lugs also keep the skip from dropping should the cables fail. Operating distance of the safety sinking skip from the last set of timber to the shaft bottom is governed by its 30-ft cables. The skip is long on economy since it can also be used for production.

Mucking: One and a half hours are required to muck out the 17-bucket round. This time includes lowering the mucker into position, mucking out the round, and hoisting the machine prior to the next blast. Observation showed that from 1½ to 2 min was the average time to fill the 3½-ton skip. Skip travel time to 500 ft was about 1 min. Slowest phase of the mucking cycle is the final bucket clean-up which takes from 10 to 15 min. Pumping water into the two skips causes an additional delay in the cycle.

Timbering: Eight by eight-foot timber was carried on 8-ft centers with one center divider for the two 5-ft inside compartments. The two wall plates were swung under the sinking skip and the remainder of the set placed inside the skip. The wall plates were hooked on the ⅝-in. hanging rods; then, with the sinking skip serving as a staging, the two end plates were placed and the set blocked. Two hours was the maximum time for lowering and placing a set of timber. To insure greater strength for the ⅝-in. hanging rods and to eliminate the possibility of severe strain opening the hooks of the rods, a 5-in. length of 2-in. pipe was placed over the two hooks of the rods.

Dead Work: The 7 ft 3 in. panel lagging was placed on all six sets with ladders and landings. In order to keep the dead work even with the sinking cycle, two men from the bottom did this work during the mucking cycle, as only one man, the Cryderman operator, was needed for all the mucking.

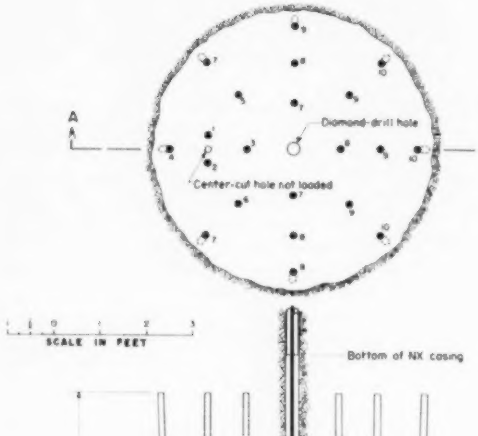


Shattuck Denn's shaft foreman, Leo Zitnik, with new shaft jumbo. Four booms mount Atlas Copco Tiger drills.

Shaft skip, made by Machinery Center Inc., uses two-cable bail, has crosshead lock feature, 70-cu ft capacity.

SHAFT SINKING BY RAISING

BETTER METHOD USES SUSPENDED CAGE



Upper diagram shows 22-hole, burn-cut blasthole pattern on typical raise mound. Holes are numbered in firing order. Lower diagram on section A-A' shows drilling platform in place at top of raise.

If you can raise—don't sink. In this case a ventilation raise was needed, but the technique could be applied to a problem that would ordinarily call for a small shaft. Safety, efficient ventilation of the working place, and effective working conditions were readily met by the method applied by Resurrection Mining Co. near Leadville, Colo.

Pioneered in 1953 by Tennessee Copper Co., the procedure calls for a shielded cage suspended in the raise by a cable lowered through a pilot hole. Ingenious approach permits a roofed cage to be carried right up to the top of the raise without head blocks, pulleys, or sheaves to set and remove.

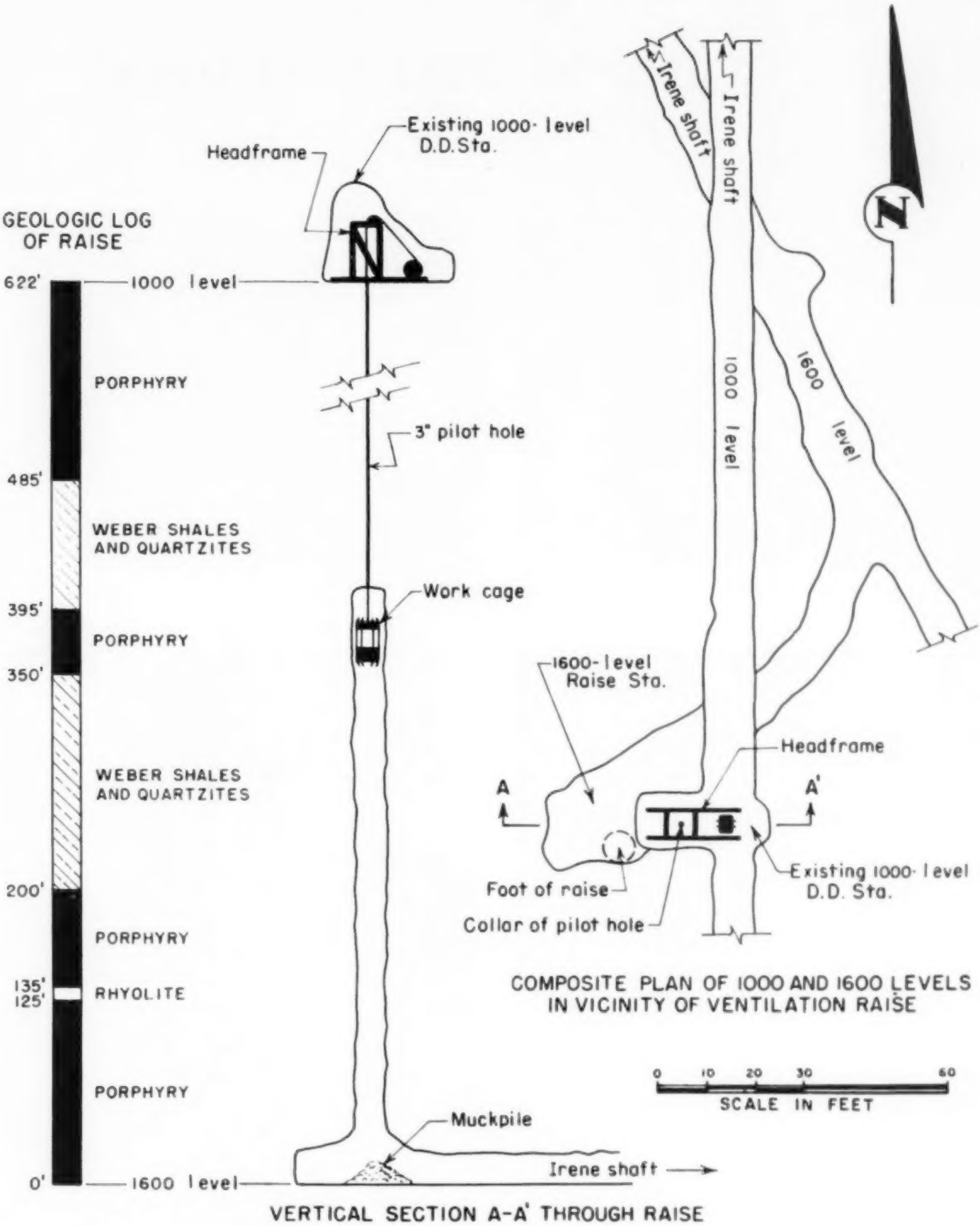
At Resurrection the existing drill hole, BX, was too small and was reamed and cased to NX size. The lower part of the hole through altered material could not be cased, so the first 130 ft were driven conventionally. The remainder of the 622 ft was driven with the cage.

Communication between lower working area and hoist above is vital. Three systems were used for this job: voice-powered telephone inside the cage, reaching levels above and below; three-way squawker signal; and direct electrical signal system between cage and hoist. A multiconductor cable was suspended below the cage, and lines were looped from the lower station, through the shaft, to the upper level station.

In their report Bolmer and Greenlee summarized results as follows: "The management and staff were pleased with the progress made and the safety record achieved with the cage method of raising. The company's initial experience suggested the following ways in which its safety and efficiency might be improved.

"1) The signal cable should be incorporated in the hoisting rope. 2) A drill hole large enough to hold the air and water pipe, hoist rope, signal cable, and possibly the blasting line would facilitate operations (6 to 8 in. diam). 3) If a larger hole was not feasible, the permanent air and water pipe and the blasting line should be recessed in a slot excavated along the rib of the raise. 4) A large station is necessary below the raise to facilitate pulling the work cage into the raise over the muck pile. 5) Unless necessary because of unstable ground, casing the drill hole should be eliminated. The crew spent 3 hr per day pulling casing.

"If the cage method of raising were repeated with the suggested improvements in design and technique, the management was confident that the crews could complete six full work cycles every 24 hr."



Three diagrams above show geologic log, vertical section, and plan of ventilation raise driven by cage method. It took 75½ shifts to drive 492 ft by cage. Total length of the 6-ft diam raise was 622 ft. NX cased pilot hole provided for hoistcable support of cage. Technique was pioneered in 1953 by Tennessee Copper Co. Figures after USBM IC7868 by ***R. L. Balmer and B. B. Greenlee.***

MOVABLE STEEL FORMS SPEED SHAFT SINKING

Relatively thin steel forms, only 5-in. from skin plate to stiffner ring, are being used for the first time in vertical shaft construction—concreting a 3000-ft shaft at Iron River, Mich. The 20-ft diam shaft is being sunk for the M. A. Hanna Co. by Walsh Construction Co. of New York.

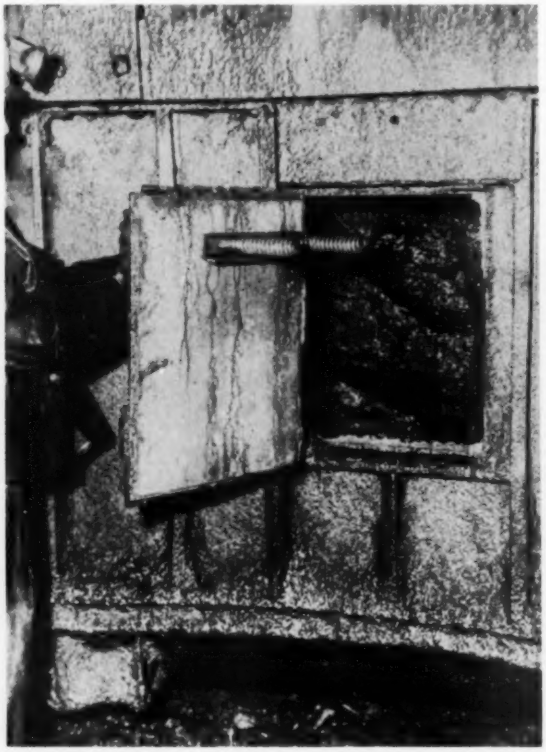
Six identical 5-ft deep sections of forms, designed and built by Blaw-Knox Co., Pittsburgh, are reducing setting time reportedly more than 60 pct, and work on the project is scheduled for completion early this year. Concrete 18-in. thick is being placed at a rate of 60 ft per week, with the contract calling for a total of 8490 cu yd.

For the job at the Homer Wauseca iron ore property the six sections of forms are bolted together to make a 30-ft high unit. Forms are moved from one position to another in 4 hr through use of anchor bolts for staging beams. As the shaft progresses, staging beams are installed at 10-ft intervals.

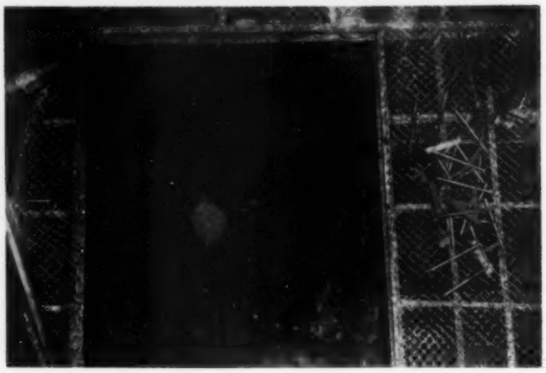
Each 5-ft section of the bolted 30-ft unit has a series of 18x24-in. hinged doors through which anchor bolts are set. Two steamboat ratchets are used to strip the 30-ft unit of forms, and the complete unit is then lowered in a single operation by a hoist at the surface.

After forms are positioned 8 hr is needed to pour 130 cu yd of concrete. Steel spreaders are then placed in the concrete for a 3-day setting-up period during which the shaft is sunk another 30 ft.

Concrete is mixed on surface and lowered in a 2-yd bucket. The bucket empties into a center hopper on the top level of the two-level working platform, then flows into a chute which revolves 360° on the lower level of the working platform. A conical bulkhead at the bottom of the forms serves as a blast deflector ring.

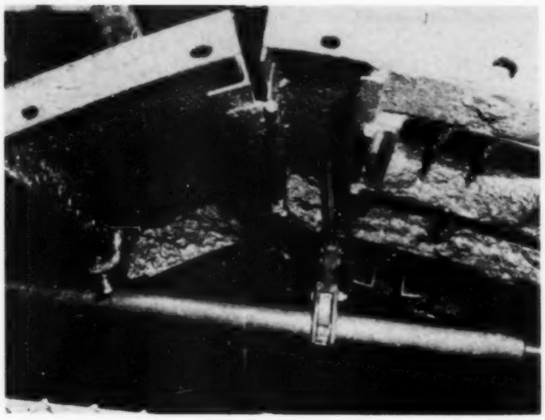


Anchor bolts set in this 18x24-in. door with each concrete pour are used for staging beams positioned every 10 ft in the vertical shaft. These same bolts are used to suspend the forms during concrete placement and setting.



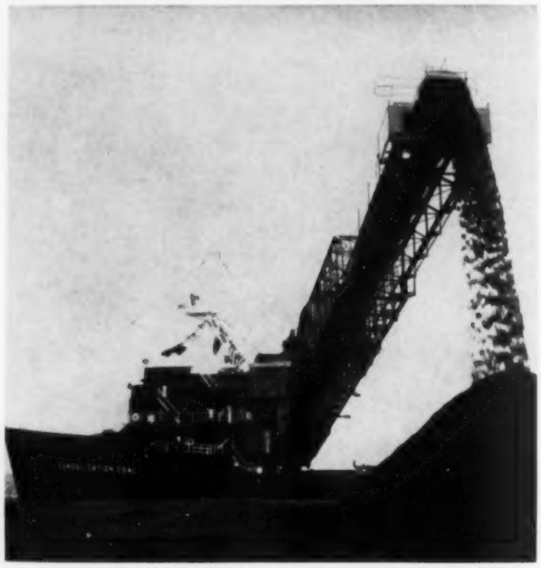
Above: Top level of two-level platform shows wire rope used for lowering the complete unit to next position. Below: A hinged door in the work platform permits muck removal while concrete is setting-up behind the steel forms.

Right: Heavy chains are used to suspend the forms unit during successive placements of concrete. See view of anchor bolts on opposite page. Below: Hinging out the key panel in the form permits lowering the entire 30-ft set of forms.

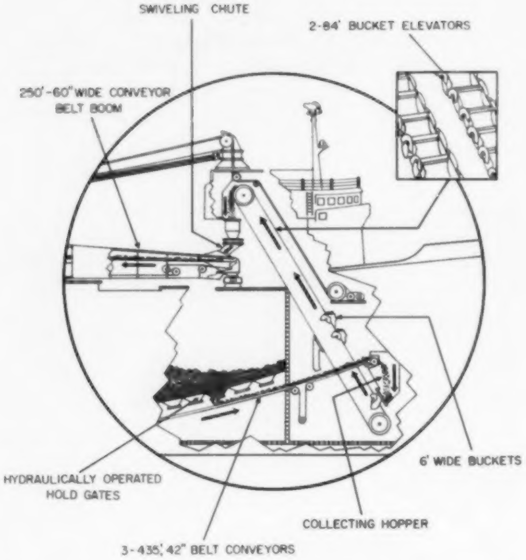


Two of these steamboat ratchets strip a 30-ft high unit of steel forms. The unit is then lowered to its next position for concrete placement.

SELF UNLOADERS . . .

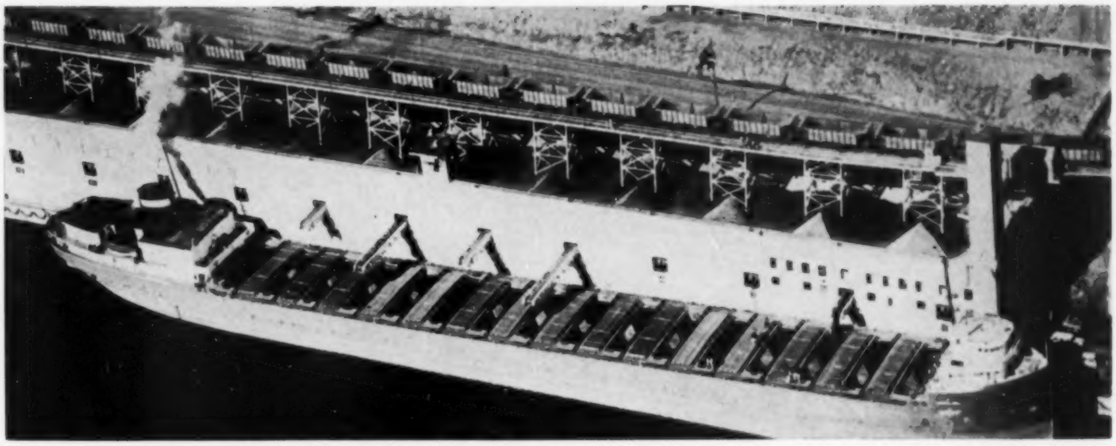


Coal spews from the hold of the new S. S. Consolidation Coal at the rate of 3600 tph thanks to a self-discharging system. The 250-ft boom conveyor requires no onshore equipment and can empty into barges at sites where the collier cannot dock. Detergent spray at boom tip allows dust-free discharge of dry coal without air pollution.



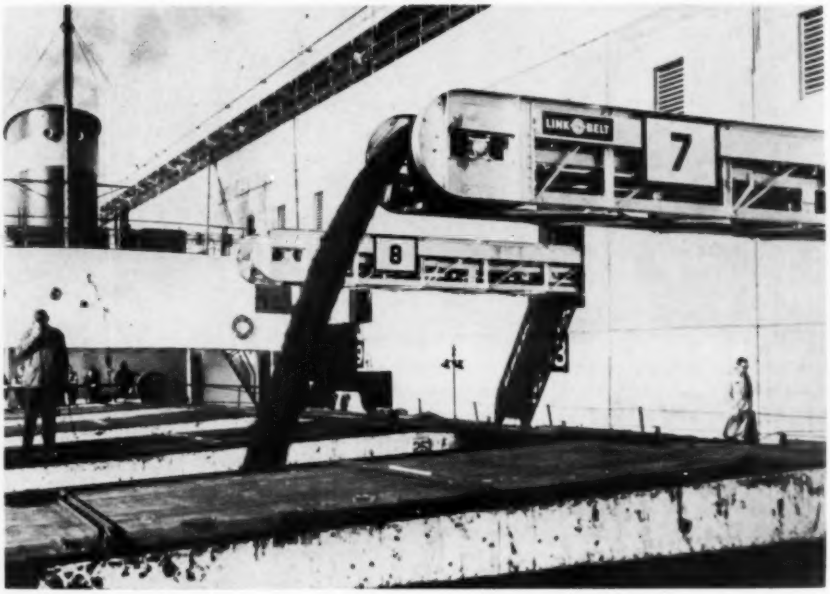
Coal is carried in seven holds equipped with 159 hydraulically-operated 36x52-in. hold gates through which the coal flows by gravity to three 435-ft, 42-in. wide conveyor belts. The three conveyors run at 650 fpm up a 16° incline. They discharge into a hopper which feeds two elevators with 6-ft buckets which carry coal out of hold.

From the bucket conveyor the coal is dumped into a swiveling chute which turns with the boom and empties onto its 60-in. wide belt. Pivoting on the spar deck, the boom can swing in an 89° horizontal arc on either side of the ship. Boom can be elevated 18° to pile coal up to 60 ft high. An intermediate plow allows discharge half way up the boom. Depending on side of discharge, entire operation can be handled from pushbutton control panels on each side of bow.

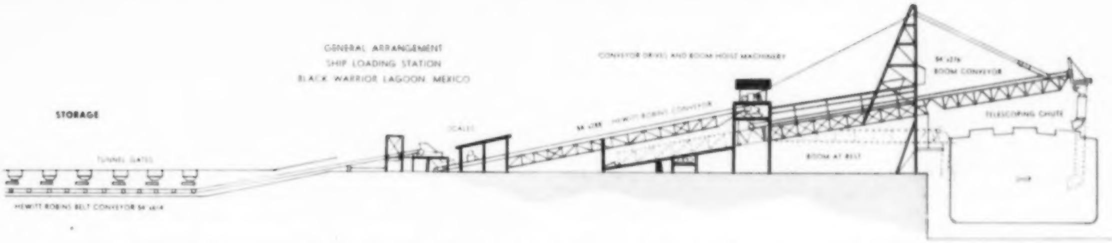


This pushbutton taconite dock on Lake Superior loads Great Lakes ore boats with pellets from 25 shuttle belts. Dock is 1200 ft long and can load two vessels simultaneously. Note ore cars on trestle above storage bins.

AND FASTER LOADERS



On vessel, mate gives instruction to control tower by portable telephone after ore boat is alongside dock and belt conveyors extended over alternate hatches. Each of the dock's 25 shuttle belts can be controlled independently to load and trim pre-set quantities to each hatch at the rate of 750 or 1500 tph.



Salt from a Mexican deposit about 400 miles south of San Diego is loaded aboard a sea-going carrier as shown above. Novel chute may be telescoped from 33 ft to almost 60 ft, tilted 10° from vertical, and rotated in a complete circle. The chute can be tilted, rotated, or adjusted to any position by a single operator stationed on the ship who controls all movements with a portable set of pushbuttons. Signal lights mounted on an outshore tower give operator constant visual information on the operation so that he can fill the holds evenly.

COAL FORECASTS RISE

Bituminous coal production in the United States is expected to rise to 455 million tons in 1959, an increase of 13.8 percent over this year's output, the National Coal Association estimated.

NCA's Committee on Coal Economics and Statistics forecast that coal consumption will increase 8.1 percent, to equal production, in contrast to this year when many consumers reduced their coal stockpiles and used more coal than was mined.

The committee predicted that 163 million tons will be mined next year for electric utilities, an increase of 7.1 percent for the nation's largest consumers of coal.

The steel industry, already back to its 1957 production rate, is expected to consume 105 million tons of coking coal in 1959, an increase of 36 percent from this year.

Other industrial use of coal is expected to gain 1.4 percent, to 106 million tons. Some users, such as cement manufacturers who will benefit from the multi-billion dollar highway program, will increase their demand for coal; others, such as railroads, will continue as a declining market, the committee said.

The forecasters said the retail market is expected to take 30 million tons of coal next year, 3.6 percent less than 1958 but a smaller decline than in most postwar years.

The market for export coal is more difficult to forecast because of "political overtones" in consuming countries, the committee said, but exports are expected to decline 8.9 percent, to 46 million tons. It forecast a 23.1 percent increase, to 16 million tons, in coal sales to Canada, but a 20 percent drop in overseas shipments, which are expected to be 30 million tons.

Total 1958 production is expected to be near 400 million tons.

FIVE-YEAR FORECAST

The NCA Board of Directors met in Washington Jan. 14 to discuss fiscal, administrative and legislative matters and to receive reports from Association officers and committee chairmen. A feature of the meeting was the report of the Committee on Coal Economics and Statistics which, at the direction of the Board, made its first five-year estimate of the demand for coal. The forecast, subject to annual revision, estimates annual consumption of 500 million tons by 1963, with intermediate years projected as follows: 1959—455 million tons; 1960— 465 million; 481 million, and 1962—489 million.

The Economics and Statistics Committee based its forecast on an estimated increase of 34.9% for electric utility consumption, reaching 205 million tons in 1963; an increase in coking coal of 42.9% for the same period, reaching 110 million tons, and an increase in general industrial use of 7.5%, or to 114

Greasing the machinery for full speed ahead in the coal industry. As might be expected in 1958, shipments of mechanical loading, cleaning, conveying, and mining equipment for use underground in U. S. coal mines decreased in comparison with the previous year—a trend in proportion to general industry production. During the year, however, continued strides were made in the technical areas of continuous mining and automation for coal preparation. Major research emphasis is being placed on ventilation for continuous miners. In another area—safety—the 1958 trends were heartening, with fewer fatalities per million tons of coal mined than in 1957. However, disasters in West Virginia in the fall overshadowed the year's average. The Springhill Mine, Nova Scotia, fatalities were not, of course, included in the U. S. figures, but did point up the bump problem, still a concern to the industry in both countries—see MINING ENGINEERING, *August and September 1958, for reports on specific mine problems including Springhill.*

million tons. Certain markets, according to the Committee, are expected either to remain static or to decline. Retail consumption and exports to Canada are expected to decline 19.6% and 8.0% respectively, while overseas exports are expected to remain at 30 million tons for each of the five years.

The Committee's forecast was made with these assumptions: (1) that there will be no recession in this period; (2) that the penetration by gas and oil of coal's markets will not accelerate and may even decline somewhat; (3) that nuclear power will not have a significant impact upon coal's markets by 1963; (4) that the cold war will continue; and (5) that the relationship of Government to the competitive energy market will not be substantially changed through regulation or subsidy or both. A material upset in one or more of these assumptions conceivably could have an important effect upon the forecast. The Committee felt that coal's future will be closely tied to that of the electric power industry, steel production, and general industrial use, in that order. The potential in electric home heating alone could materially increase even the 35% consumption increase projected. Economical nuclear power is now recognized to be longer in the future than believed even a year ago.

The Committee met in Washington a day ahead of the Board meeting in order to check its calculations and consider other projects in progress. Another NCA committee—Public Relations—also met on Jan. 13 to hear staff reports on educational, advertising, publicity and other activities.

SYMPOSIUM ON MINING PRODUCTION CONTROL

Increased efficiency, higher production with reduced cost, and improved technical developments were the topics stressed by speakers at the Symposium on Mining Production Control as part of the Annual Conference for Engineers, on the Ohio State University campus, Columbus, Ohio, May 2, 1958. Over 1000 engineers in addition to students and faculty attended the sessions.

Following are abstracts of all the papers that were presented at the Symposium:

Is Mining Production Control Necessary by *F. Mason Morgan*, manager, Industrial Engineers, North American Coal Corp.

The urgency of the need for increased productive efficiency in coal mining can be seen by considering the significant period from 1947 to 1958. During that time, labor costs increased 117 pct while productivity increased only 70 pct. During the same period, the cost of mine machinery almost doubled while the price of coal remained about the same.

The growth in popularity of the formal application of industrial engineering principles to the search for a solution to the problem is only one of the results. Manufacturing industries have demonstrated their effectiveness, especially on repetitive production lines, but few coal companies, until just recently, have made formal attempts to apply them to increase profits by achieving more efficient use of labor.

Our relatively new industrial engineering program has already produced results such as: 1) length of cutter bars for most efficient operation in various mining conditions; 2) spotlighted productivity differences among crews and individuals in these crews; 3) production standards under varying conditions with given equipment.

Time Study Phase—Equipment Manufacturer's Advantage by *E. H. Hobden*, manager, renewal parts sales, Jeffrey Manufacturing Co.

Industrial engineering, as applied to mining, is a scientific approach to problems in production and operations with improved reflections expected in product cost. As a manufacturer, serving the coal mining industry, we have great interest in the application of this approach for improvement in tons per man on a section, in a whole mine, in a company.

Equipment time studies, when fully analyzed, will point out the equipment pieces leading the production cycle, and thereby challenge the operator to improve methods or the manufacturer to improve retarding units. Too, it points up the potential in combining one or more of the separate operations in mining.

Studies are usually made more frequently on the following types of equipment: 1) shuttle car—includes all phases of operation—loading, maneuvering, travel, discharge, place change and delays; 2) loader—includes loading time, maneuvering, car change, place change, delays, and mechanical breakdowns.

No one familiar with the coal mining industry will question the manufacturer's acceptance of the obligation to advance engineering and development of equipment. A mining equipment manufacturer supports total engineering, research and development, and in general to a greater degree dollarwise than total sales. For instance, of the total engineering dollar expenditure, more than 60 pct is research and development.

Work Measurement and Cost Control by *Ralph B. Dean*, administrative assistant, The Lorain Coal and Dock Co.

The principles of industrial engineering applied to our Company's coal mining operations provide management with a tool to determine the volume of tonnage that we can expect and at what cost. This concept of management calls for management of work and control of money spent.

Heavy emphasis is placed on face work standards which are developed by: 1) timestudies of all the jobs at the face; 2) recording and collection of much timestudy data in a basic data book; 3) this data when completed being used for setting standards for any operation, using any machine, and under any classified condition at the mine.

After standards have been set for all mining operations on a section, the operation that requires the longest time is considered to be the "controlling cycle," which ideally should be the loading function. This cycle is called 100 pct tonnage, but 80 pct tonnage represents a fair budget that can be expected day in and day out by alert management.

There are three basic assumptions inherent in the philosophy of the cost control phase of our program: 1) All costs in mining can be controlled. 2) Total cost must be broken down into each element of expense. 3) These elements of expense are to be controlled at their point of origin.

From these assumptions an integrated cost control program can be developed. This in turn calls for a functional operating organization, a cost accounting system, standards for labor and supply costs, and incentives for reaching and maintaining these standards.

As an operating guide to supervisors, a daily operations report that shows the weekly budget for tonnage, labor, and material by section is compiled. The daily and month-to-date production and costs are posted in this report showing a comparison to the budget. Each key man receives daily the report that will show him how his performance compares

Among those on the speakers' platform are, left to right: E. H. Hebden, Jeffrey Manufacturing Co.; F. M. Morgan, North American Coal Corp. (speaking); Ralph Dean, Lorain Coal and Dock Co., Myron Kok, Warner Collieries, and J. Richard Lucas, Ohio State University.

with the budget for which he is responsible and has authority to control.

The results obtained through the use of this program have been gratifying. From 1951 to 1954 our direct cost of mining had been reduced by about 25 pct and face tpd had increased by 40 pct without elaborate equipment changes.

Prerequisites for Successful Application of Incentive Plans by *Myron Kok*, vice president, The Warner Collieries Co.

Our company has no special panacea except that we do heartily endorse and accept the principle that proper application of industrial engineering techniques can reduce the cost of production from 10 to 40 pct.

Industrial engineering techniques as applied to coal mining include the establishment of proper work methods, balance of face cycles, cost, delay, and supply controls. Techniques are also used to establish wage incentives for management as well as worker.

Many items of cost, such as rental, insurance, labor, benefits, are fairly uniform and easily predicted. The most difficult items to predict are labor cost and production of tons mined. Because labor represents 60 pct of total production cost, much emphasis is placed upon this area.

Reducing labor costs or increasing productivity per man can be achieved by a) installing better equipment to replace bottleneck units or to replace men; b) installing improved methods and encouraging the men to develop more skill and effort.

After better methods have been installed, productivity can be increased further if there is additional effort by the men (supervisors and workers). Wage incentives are the answer here. Many coal companies are at present paying a wage incentive to their management personnel. One company experienced a 20 pct productivity increase in an operation that previously had no work measurement and no incentive.

Sound wage incentives are a method of paying full value for effort beyond the timestudy standards. Proper wage incentives point out wasted time. The Society for Advancement of Management has established the fact that the average worker will produce 75 pct of a normal day's work with no incentive, while with an incentive he will average 115 pct of a normal day's work.

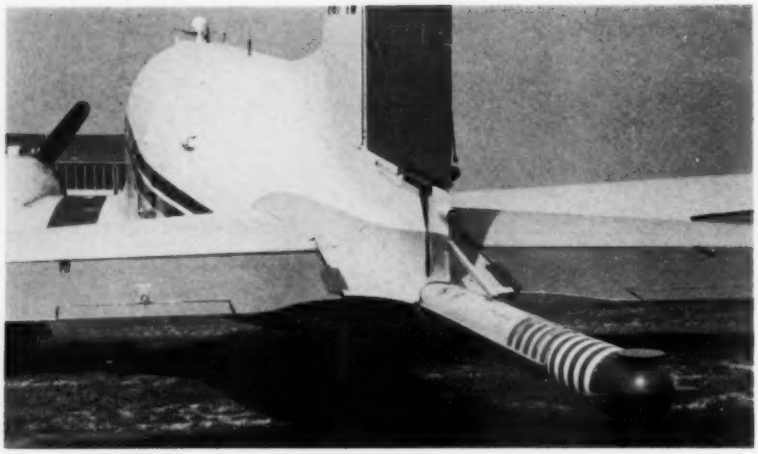
The workers should be paid the same pct increase in wages as the pct increase in their effort over the standard requirement. That is 1 pct of base pay for 101 pct of the standard, 10 pct of base pay for 110 pct and 25 pct for 125 pct of the standard.

Improvements attained with a cost reduction program are measurable. Daily controls can be set up to show a comparison of standard and actual costs. A daily profit and loss statement for each section of a mine and the total mine is a practical matter. Delay controls can be set up to show the waste dollars resulting from each delay.

Our experience has shown that considerable savings can be realized through this type of cost reduction program. The total labor cost in three years was reduced 55 pct. Face performance has risen from 17 tons per face man to over 50 tons with a 12 man crew. All this was done with the same men and supervisors.

REPRINTS AVAILABLE

Copies of the above papers may be obtained by writing Professor J. Richard Lucas, Mining Engineering Division, The Ohio State University, Columbus, Ohio.



Stinger installation of airborne magnetometer on DC-3 used in Sahara surveys, provides dependable magnetic data in spite of rough desert air.

NEW NAVIGATION AID TO AERIAL EXPLORATION CUTS COSTS

Aerial exploration of remote or faceless areas of the earth now can be done at a fraction of the time and cost of older methods, say geophysicists of Aero Service Corp. Radan, a new radar Doppler aid to navigation produced by General Precision Laboratory Inc., is the answer. It guides the survey plane over jungle, desert, muskeg, or water—without ground stations.

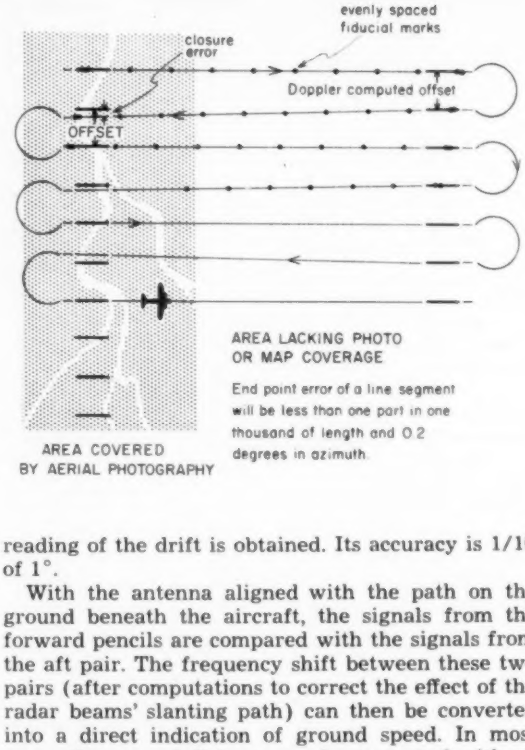
The mapping and exploration company estimates that Doppler navigation cuts survey time by 40 pct. It reduces costs by 50 pct or more, compared with other radio-guided surveys. It permits air surveys over areas previously considered too difficult—or impossible.

First Survey: The world's first airborne geophysical survey guided by Doppler is now nearing completion and aerial magnetic data is being compiled. It called for the exploration of 40,000 sq miles of the central Sahara Desert in southern Libya, with oil as the target. The exploration instrument was the Gulf high sensitivity magnetometer, veteran of 4 million sq miles of aerial surveys.

Preliminary inspection of the area established that many parts lacked recognizable features. No accurate flight or exact reconstruction of an airborne magnetometer survey could be made by conventional methods.

Direction Measured: The Radan navigator measures direction by transmitting four columns or pencils of radiation downward from the aircraft. Two are transmitted fore, and two aft. They create a pattern on the ground in which each of the pencils would arrive at the end of an X-shaped pattern.

The Doppler *return* or *echo* frequency shifts from the two diagonal pairs of pencils are compared. If the frequencies differ, then the antenna is not aligned with the actual path being flown and a side wind is causing the aircraft to drift. This frequency difference actuates a servo-mechanism which rotates the antenna so its axis is aligned with the path of the aircraft and the difference signal is reduced to zero. By comparing the angle of the antenna array and the center line of the aircraft, a direct reading of the drift is obtained. Its accuracy is 1/10 of 1°.



With the antenna aligned with the path on the ground beneath the aircraft, the signals from the forward pencils are compared with the signals from the aft pair. The frequency shift between these two pairs (after computations to correct the effect of the radar beams' slanting path) can then be converted into a direct indication of ground speed. In most cases, the ground distance can be measured with an accuracy of 1 part in 1000 or better.

Roughness of terrain causes no errors in the Doppler signal. Frequency shifts alone—not the length of the path to the ground—affect the readings of the Radar device.

The Radan navigator provides drift angle and ground speed. A compass indicates the deviation of the centerline of the ship from magnetic north. The sum of the drift angle and the compass reading is the track angle being achieved by the aircraft.

GEOLOGICAL SURVEY MARKS YEAR OF HIGH ACHIEVEMENT

The Geological Survey, now approaching its 80th Anniversary, has achieved new heights in its geologic and water resources investigations, in mapping, and in its stewardship of mineral resource development on Federal and Indian lands, Secretary of the Interior Fred A. Seaton reported in the Department's annual report.

Data required for the location of dam sites, mineral exploration, and for many engineering activities are being obtained with increasing effectiveness through the application of photogrammetric techniques. The Survey is meeting a greater demand for solution of complex water problems at a time of inadequate industrial and domestic supplies by giving increased attention to the analytical, interpretive and research phases of its investigations. Pioneering applications of several physical sciences to the development of new theories and practices in mineral exploration is illustrated by present trends in geophysical, geochemical, and geobotanical prospecting.

In addition to its regular program of research in the earth sciences, the Survey's Geologic Division provided technical data and evaluations to many Government agencies, nearly half of its funds being expended on work of this type. Largest program was for the Atomic Energy Commission. Data and services were also provided to the Armed Forces, International Cooperation Administration, Defense Minerals Exploration Administration, Office of Minerals Mobilization, Bureau of Public Roads, General Services Administration, many State agencies, and others.

Much geologic work entailed mapping near centers of ore production to clarify the principles controlling large ore concentrations. Mapping in the Holy Cross quadrangle, Colorado, for example, disclosed a several-mile-wide shear zone aligned with the trend of the Colorado Mineral Belt. This zone may have controlled the emplacement of deposits. Mapping on the Boulder Batholith in Montana shows that younger rocks west of Butte may conceal extensions of this major copper district.

Continuation of the Geological Survey's present program in topographic mapping provides the Nation with the detailed maps required for discovery, use, and conservation of our natural resources; for the planning and building of transportation structures—highways, railways, power lines, pipelines; and for the multitude of other uses which require accurate, detailed knowledge of terrain.

During the 1958 fiscal year, 1600 new quadrangle maps were published and a great many others were reprinted. Standard urban area maps were printed for 12 cities. Cooperative projects were in effect in 32 States, Puerto Rico, and the Virgin Islands.

As the Nation's population increases it becomes more and more conscious of the need for abundant water supplies. The Geological Survey through its geologists, engineers, chemists, physicists, and mathematicians locates and describes available water resources, determines the amount of water available, and the extent to which it can be developed without depleting the supply or impairing quality.

The Survey is responsible for classifying Federal lands as to mineral and water resources, and the supervision of mineral-recovery programs under leases, permits, and licenses on Federal, Indian, and Outer Continental Shelf areas. As a result of this activity $82 million in royalty income to the Government was received for distribution to States, special funds, Indian lessors or the Federal Treasury. All income from Restricted Indian land is received for the benefit of the tribe or allottee.

Funds available from direct appropriation and from cooperating agencies for supporting the Survey's programs amounted to nearly $59.5 million, of which about $18.3 million was spent for topographic mapping, $15.4 million for geological surveys, $21 million for water resources investigations, and $2.4 million for conservation activities—and $2.3 million for administration and building construction.

Results of these activities were made available through some 4,169 maps and reports published last year by the Survey, by technical journals, cooperating agencies, and open file releases.

USBM REPORTS ON WEST VIRGINIA MINE DISASTER

Ignition of explosive gas by an electric arc or spark caused an explosion that resulted in the death of 14 men and injury of three others at the Oglebay Norton Co.'s Burton coal mine near Craigsville, Nicholas County, W. Va. The disaster occurred on Oct. 28, 1958, and has been investigated by the Bureau of Mines.

The Bureau reported rock dust (powdered limestone) prevented spread of the explosion throughout the mine and permitted the other 37 men underground to escape without assistance.

The Bureau report is based on its own studies, on evidence collected during a joint underground investigation, and on testimony by officials and employees during an official inquiry at Craigsville last November 3.

The underground investigation was made by a committee on which James Westfield of Washington, D. C., assistont director, Health and Safety, was the senior Bureau representative. Others included representatives of the West Virginia Dept. of Mines, the Oglebay Norton Co., the Bituminous Coal Operators Assn., and the United Mine Workers of America.

W. R. Park, district health and safety supervisor of Mount Hope, W. Va., and Federal coal mine inspectors Francis H. Henderson and Arthur Charlesworth, also members of the Bureau's team, wrote the formal report on the disaster, which says, in part:

"The Federal investigators are of the opinion that the disaster was caused when a large quantity of methane, released from formations in the roof by large falls or emitted from heaving bottom in the active workings in the 15 left section, accumulated in the active working areas and was ignited."

Gas accumulated in these working areas when the ventilating current was short-circuited in the active workings by the removal of brattices from crosscuts between the 15 left entries.

"The gas was ignited by an electric arc or spark-initiated when a roof fall caused the power wires in No. 2 entry to contact the return conductors or the frame structure of the belt conveyor."

Coal dust in the face regions slightly added to the explosion and aided in its propagation.

A typical mine rescue team practices at a simulated disaster area to prepare for sudden emergency. This team is at the Sullivan mine of Cominco, setting a jack post to prevent weak ground from giving away. Proper use of safety equipment—such as hard hats, cap lamps, and oxygen rebreathing apparatus—plays a vital role in the team's preparation for prompt emergency action.

BRIEF ON WORK INJURY AND EMPLOYMENT DATA FOR MINERAL-EXTRACTIVE INDUSTRIES, 1955 TO 1957

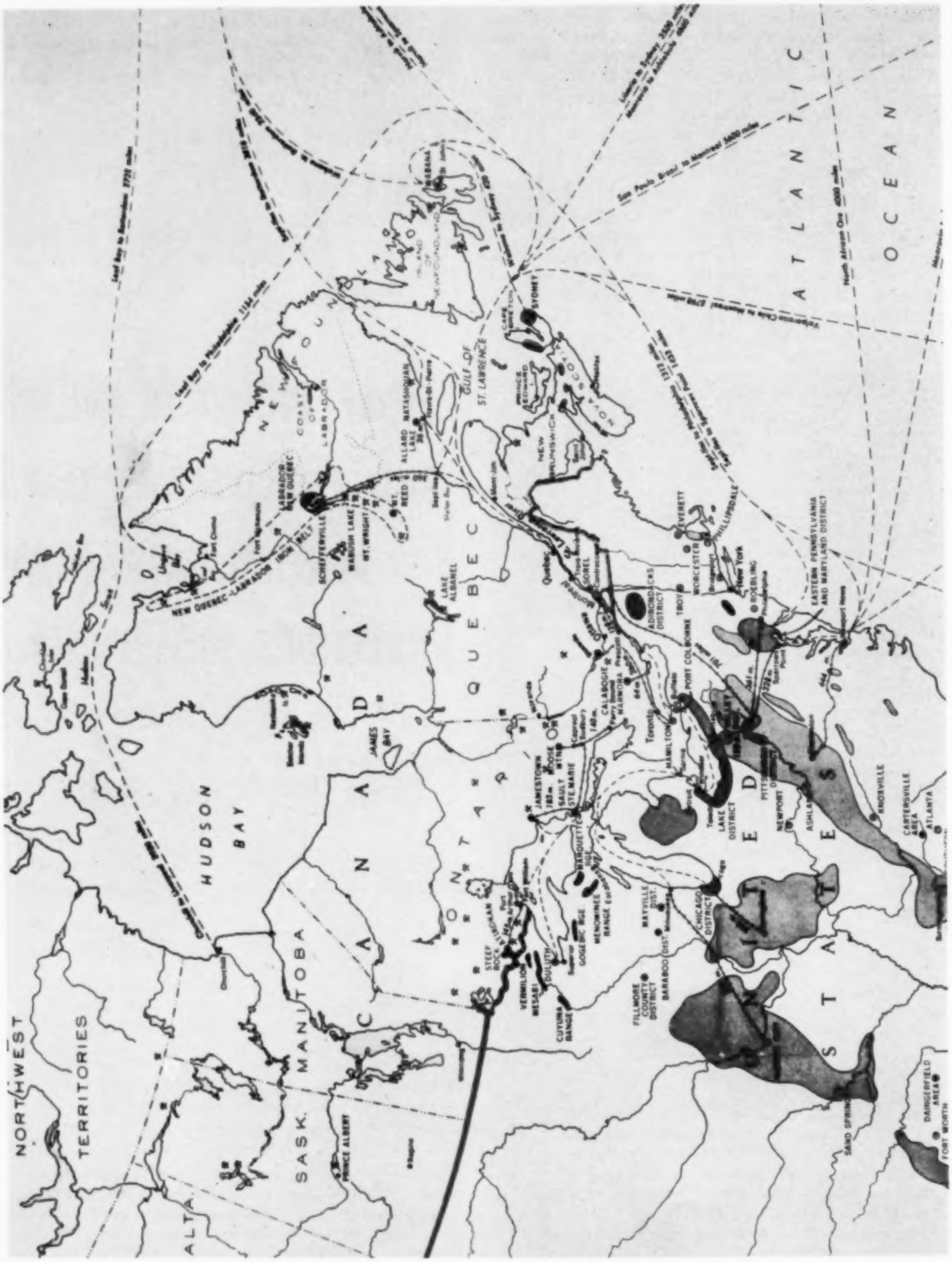
The preliminary injury-frequency rate (fatal and nonfatal combined) for production and development workers in the U. S. mineral-extractive industries during 1957 was 23.35, a decline of 6 pct from 24.78 in 1956, according to reports received in the Washington Office of the Bureau of Mines, U. S. Dept. of the Interior, prior to June 15, 1958. These reports cover approximately 99 pct (based on men employed) of the mineral industry reporting in 1956. Data for 1955 and 1956 in this report have been revised and final figures are available. Employment and injury data for anthracite coal, coke, and petroleum and natural gas industries are final; all other 1957 data are preliminary and are subject to revision.

One new industry, peat, was added to those canvassed during 1957 for injury and employment data. Of the eight groups for which data are available for both 1957 and 1956, five showed an improvement in the frequency of occurrence of disabling work injuries (fatal and nonfatal) to production and development workers in the mineral industries. These five industries were: coke, from 5.50 in 1946 to 4.46 in 1957; petroleum and natural gas, from 11.52 to 11.01; nonmetal mills from 28.62 to 22.71; metal mining from 37.49 to 33.04; and coal mining from 46.73 to 44.16. The remaining three industry groups reported increased frequency rates in 1957—metallurgical plants from 14.94 in 1956 rose to 15.43 in 1957; stone quarrying from 21.34 to 23.72; and nonmetal mining from 31.00 to 31.06. The increase in the frequency of lost-time injuries at nonmetal mines was very slight.

The fatality rate for all mineral industry groups was the same in 1957 and 1956—0.44 per million man-hours. No fatal injuries were reported by the peat industry in 1957, the first year injury and employment data were collected for this mineral industry. The frequency of fatalities per million man-hours worked for metallurgical plants was 0.12 in both 1956 and 1957. The following industry groups reported decreased fatality frequency rates in 1957: nonmetal mines, from 0.50 in 1956 to 0.27 in 1957; metal mines, from 0.62 to 0.46; petroleum and natural gas, from 0.15 to 0.13; and nonmetal mills, from 0.17 to 0.15. Increased fatality rates were reported by the coke, coal-mining, and stone-quarrying groups. The frequency of nonfatal injuries per million man-hours of exposure to the hazards of mineral extraction for all mineral groups in 1957 declined 6 pct—from 24.35 in 1956 to 22.92 in 1957.

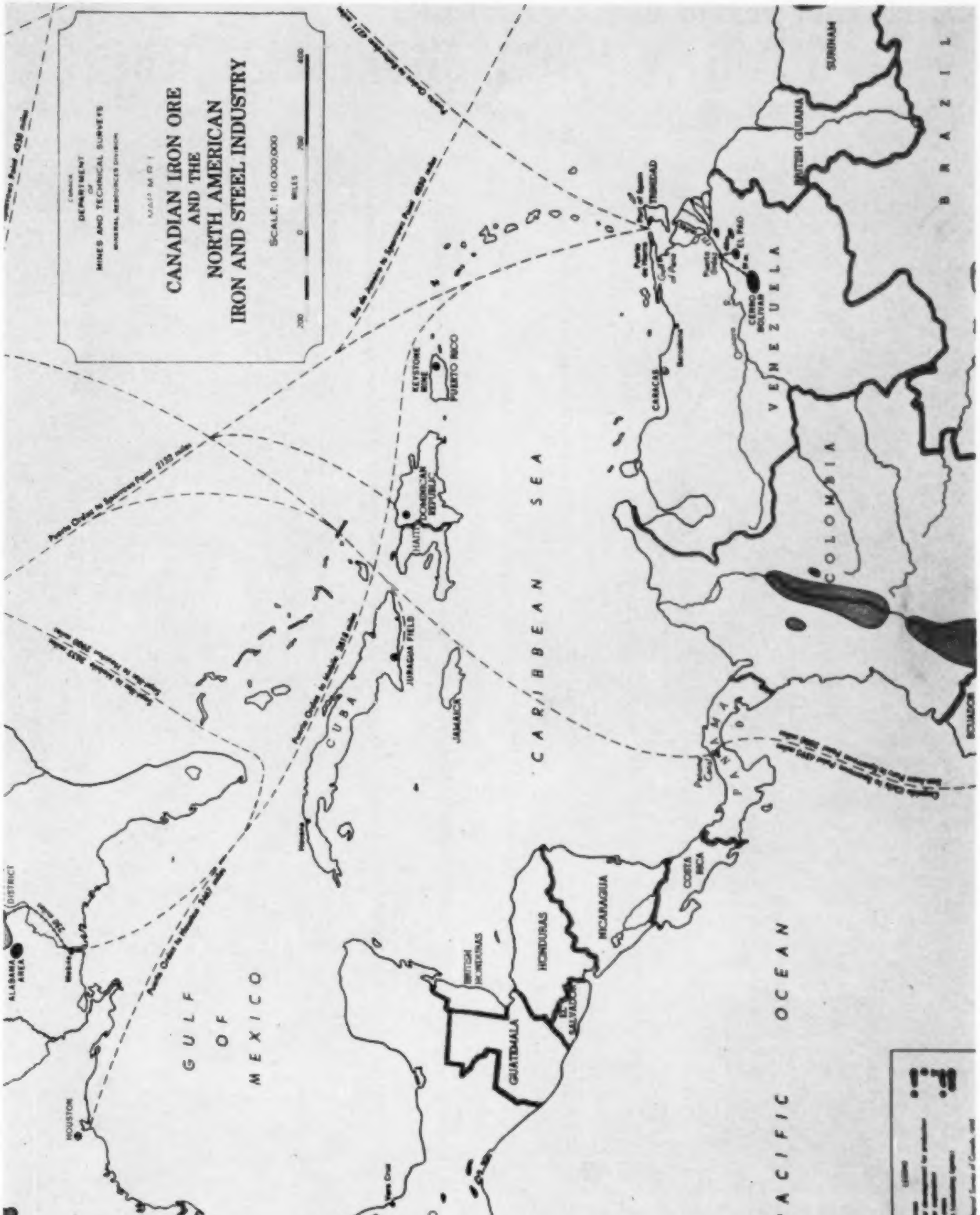
Time-loss information was first collected in 1956 for the following industry groups: metal mining (except placer mining), nonmetallic mining, metallurgical plants, and nonmetal mills. Thus a severity rate per million man-hours became available for these groups for the first time in 1956. Since time-loss information is not collected for the placer, peat, stone, and coke industries, an *all-industry* severity rate is not available for any of the three years presented here. The lack of time-loss information for the placer-mining industry prevents the computation of a total metal-mining industry severity rate. The severity rates for the coal-mining industry (anthracite and bituminous) are not available for 1957 as the data for bituminous coal are a projection based on a monthly sample and published monthly in a series entitled *Coal Mine Injuries and Employment*. No attempt was made to project or estimate the degree of injury or the time loss for nonfatal injuries. In the four groups for which severity rates are available for both 1956 and 1957—petroleum and natural gas, nonmetal mining, metallurgical plants, and nonmetal mills—all except metallurgical plants showed a decline in the severity of *total injuries* to production and development workers in 1957. The severity rate for nonfatal injuries declined for nonmetal mills but increased for petroleum and natural gas, nonmetal mining, and metallurgical plants.

CANADIAN IRON ORE SURVEY



Iron ore producing areas are shown as ragged black areas; Canadian areas under development for production as round black areas, Canadian areas under exploration as crosses, iron ore consuming areas and coal producing areas (excluding lignite) are shown by shaded areas and dots.

During 1958 development and expansion of Canada's iron ore deposits continued to attract attention. The map shows the relationship of deposits to major markets.



Map MR1 from Canada Dept. of Mines & Technical Surveys, Mineral Resources Div. Cartography by the Geological Survey of Canada, 1958.

UNITED ENGINEERING CENTER PROJECT

Continuing to interest—and concern—engineers during 1958 was the status of the proposed United Engineering Center, new home of the five Founder engineering societies (AIME, ASME, ASCE, AIEE, and AIChE). To be built on First Ave. in New York, between 47th and 48th Sts., opposite the United Nations building, the Center's 20-ft tower will symbolize engineering's importance in the world of today and tomorrow. Campaign for funds will continue during the coming year.

GEOCHEMICAL STUDY OF SOIL CONTAMINATION IN THE COEUR D'ALENE DISTRICT, SHOSHONE COUNTY, IDAHO

by F. C. CANNEY

Geochemical prospecting seeks hidden mineral deposits by sampling for variations in the chemical composition of naturally occurring materials. Usually the samples are of soils and other products of weathering and erosion—surface materials extremely susceptible to contamination by human activities. Except when a survey is conducted well away from populated areas, contamination is an ever-present hazard.

The program's success is particularly endangered when the contaminants are the elements sought; if these occur erratically throughout an area, spurious anomalies completely unrelated to mineralized areas can be formed. Evenly distributed contamination can be dangerous too, if it raises the background to such a level that true anomalies can no longer be easily detected. Suppose, for example, that in an area where the lead background is 20 parts per million the soil over a lead vein contains 1000 ppm of lead. Here the contrast would be 50 to 1, which is very satisfactory for geochemical surveying. Now if 1000 ppm of lead from some source were added evenly to the soil in this area, the contrast would be reduced to about 2 to 1, and the anomaly would no longer be readily detectable because a threshold of significance twice the value of the background is the minimum generally used for interpreting geochemical data.

Of the many possible sources of contamination, probably most important are smelter fumes, which may distribute large quantities of metal contaminants over many square miles of ground.

For several reasons, the investigation reported here was begun in the Coeur d'Alene district in northern Idaho: 1) a lead smelter has been operated in this district since 1917 and an electrolytic zinc plant since 1928, and presumably the contamination patterns are strongly developed; 2) to evaluate the usefulness of certain geochemical techniques, V. C. Kennedy and S. W. Hobbs of the USGS had already studied the distribution of copper, lead, and zinc in the soils (both in background areas and other veins) and in the water and plants, providing a criterion for measuring the magnitude and effect of soil contamination; 3) one of the economically important parts of the district lies south of the South Fork of Coeur d'Alene River and within a radius of five miles of the reduction plants near Smelterville (Fig. 1). In this area, and in the entire district, conventional methods of prospecting are hindered by heavy vegetation and thick soil cover, and the possibility of contamination by smelter fumes has discouraged geochemical prospecting. Should data reveal that geochemical prospecting could be done successfully in such an area, a particularly useful tool would be available to mining companies and prospectors searching for concealed orebodies in this economically important part of the district.

The field work on which this report is based was done from July 28 to 31, 1955. It should be emphasized that this was reconnaissance study only, and therefore far from exhaustive.

Previous Investigations in U. S. : The first geochemical survey known to have been affected by contamination was conducted in 1940—a geobotanical reconnaissance made in the Michigan copper district by a private company. Geologists found striking variations in the copper content of oak and maple leaves, but unfortunately the high copper isograds of the study seemed to be related more to the Calumet and Hecla copper smelter fall-out than to mineralized ground.[1] The leaves of one oak tree near the smelter contained 0.4 pct Cu.

Similar contamination was reported by Clarke (Ref. 2, p. 41), who conducted experimental geochemical soil and botanical surveys at Ray, Ariz. He found that the leaves of oak trees growing in unmineralized ground near Superior, Ariz., contained more copper than the leaves of oak trees growing on the capping of the Ray orebody and attributed this fact to contamination from the fumes of the Magma smelter at Superior. According to H. E. Hawkes,[3] soils and stream sediments in the Superior area are also severely contaminated. Hawkes' work there has shown a copper content averaging 0.5 pct in the surface horizons of soils within one mile of the smelter stack. Samples taken only a few inches below the anomalous surface samples showed only background copper values.

In 1950 L. C. Huff[4] of the USGS made a geochemical survey in an area near Jerome, Ariz., and found considerable zinc and copper in the soils over unmineralized basalt close to Clarkedale, Ariz., and over limestone close to Jerome. As the amounts were notably greater than could reasonably be expected to be derived from the underlying rocks, Huff suspected airborne contamination from the smelter at Clarkedale.

Description of Area: The area sampled in detail (Fig. 1) for the study presented here is one of strong relief. The dominant watercourse is the westward-flowing South Fork of the Coeur d'Alene River. East of Kellogg the South Fork flows in a rather narrow canyon, but its valley floor widens considerably to the west where much of the flood plain is covered by an extensive veneer of mining, milling, and smelting debris. South of the South Fork and between Big Creek and Pine Creek is a mountainous area where

F. C. CANNEY is a Geologist with the Mineral Deposits Branch, U. S. Geological Survey, Denver, Colo. TP 4784L. Manuscript, May 8, 1958. New York Meeting, February 1958. AIME Trans., Vol. 214, 1959.

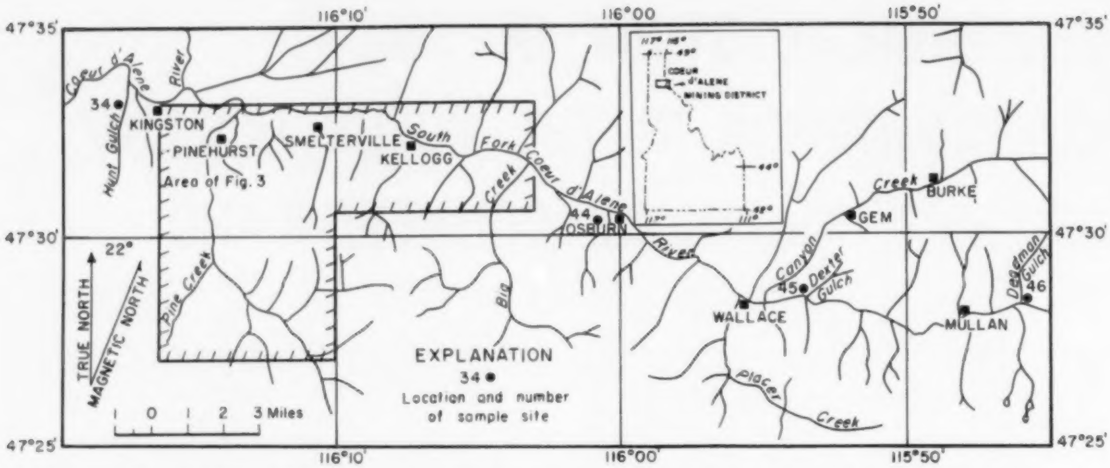


Fig. 1—Map of part of Coeur d'Alene district, Idaho, shows outlying sample sites and area sampled in detail.

many of the ridge crests and peaks rise 1500 to 3000 ft above the valley floors. The tributary gulches that enter the South Fork from the south are mostly short and steep-sided.

For some distance around the smelter most of the vegetation has been killed by the fumes. Surrounding the almost completely denuded region is a barren bordering zone covered with grass, stunted shrubs, and small trees. Where the vegetative cover has been destroyed, the soil is extremely susceptible to erosion.

Sample Collection and Analysis: To guide the location and spacing of the sample sites, two assumptions were made: first, that the heaviest contamination would be found along the sides and floor of the valley of the South Fork of Coeur d'Alene River, and second, that the profile of particle fall-out from the smelter fumes would resemble an asymmetrical curve skewed to the east, downwind of prevailing winds.

Accordingly a basic traverse (labeled AA' in Fig. 2) was located roughly parallel to the South Fork in a general easterly direction. The smelter area near Smelterville was, of course, the focal point of the sample pattern. Since time was short, the sample sites had to be reasonably accessible by car; this, and the somewhat limited distribution of terrace gravels (the material sampled wherever possible) account for the lack of a definite factor controlling the interval between samples.

Of the 46 sites visited in this investigation, 42 (those in the area sampled in detail) are shown in Fig. 2, and the rest (four outlying sites) in Fig. 1. It will be observed that in addition to the sites along AA' there are many others in several of the major gulches, especially to the east of the smelter area. Sites were also located in the Pine Creek drainage to furnish data that would show the extent of soil contamination from fumes that cross the intervening mountainous area.

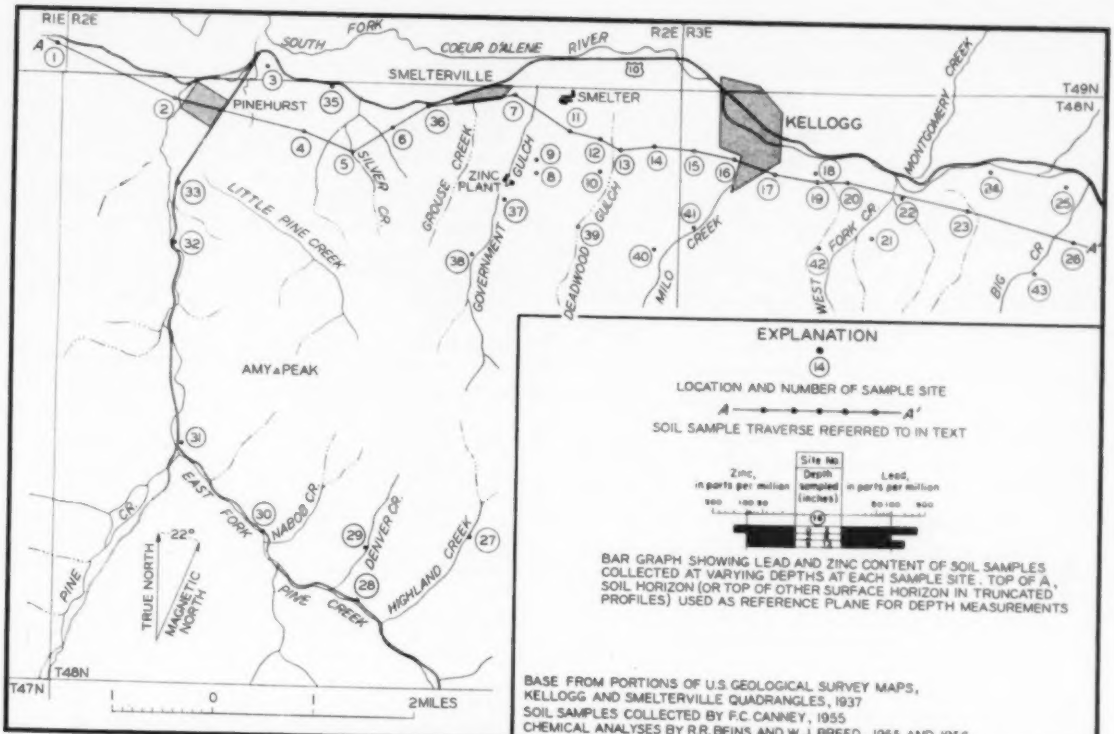
For the ideal sampling medium the author wanted a soil that had developed from parent material relatively uniform in its lead-zinc content and probably without abnormal amounts of these metals.

Extensive patches of terrace gravels mantle many of the slopes in a strip about one mile wide bordering the South Fork on its southern side. Although they are called gravels, the materials in the surface layer of these deposits—at least at most of the samples sites visited in this investigation—are mainly in the clay, silt, and sand-size fractions, with only very scattered well-rounded pebbles and cobbles. Deposited by river action, this material is a naturally composited sample of all the rock types in the river's drainage basin. It is therefore believed that the soils developed on these terrace gravels were originally of fairly uniform, low heavy-metal content similar to the metal content of residual soils developed on the sedimentary rocks—although perhaps somewhat lower, since there was probably more quartzose material in the gravels. All sample sites on traverse AA', therefore, were located in areas of the terrace gravels. However, of the sites off traverse AA' only two—9 and 34—are in areas of terrace gravels; the rest are located where soils have developed directly from weathering of the slightly metamorphosed sedimentary rocks of the Belt series of Pre-Cambrian age. In these areas, sites were selected where no mineralization was evident in a cursory examination of the immediate vicinity.

To determine the depth of contamination, profile samples were collected at each site. The desirability of sampling individual horizons in the soil profile was considered, but much of the soil had been washed away, especially in the barren zone surrounding the smelter area, and it was decided to sample at fixed vertical intervals. At 22 sites vertical channel samples were collected through each of the following intervals: 0 to 2 in., 2 to 6 in., and 6 to 12 in. The top of the A_1 soil horizon was used as a reference plane for depth measurements where it was present; in truncated profiles, the top of any available surface mineral horizon was used. At the remaining 24 sites only two samples were taken, one from the 0 to 2-in. interval and the other from an interval of about 1 in. centered at a depth of 6 in. At certain sites, samples of the surface material also were collected, either humus from the A_0 horizon, or the top half-inch of the surface mineral horizon.

About 25 g of material were collected for each sample. R. R. Beins and W. J. Breed of the USGS laboratories analyzed the samples for lead and zinc by rapid colorimetric field methods, which are usually precise to within ± 30 pct. The size fraction

DETAILED RESULTS OF INVESTIGATION



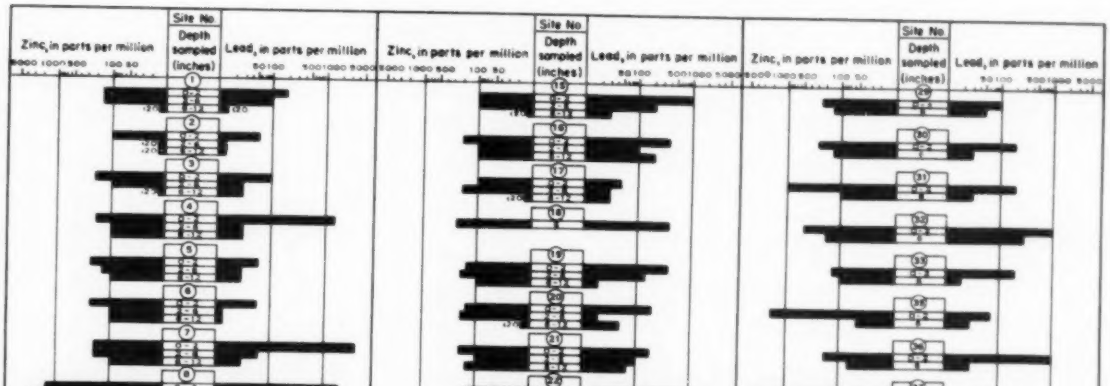


Fig. 2A (top)—Map showing sample sites. Fig. 2B (bottom)—Histogram showing lead and zinc contents of samples.

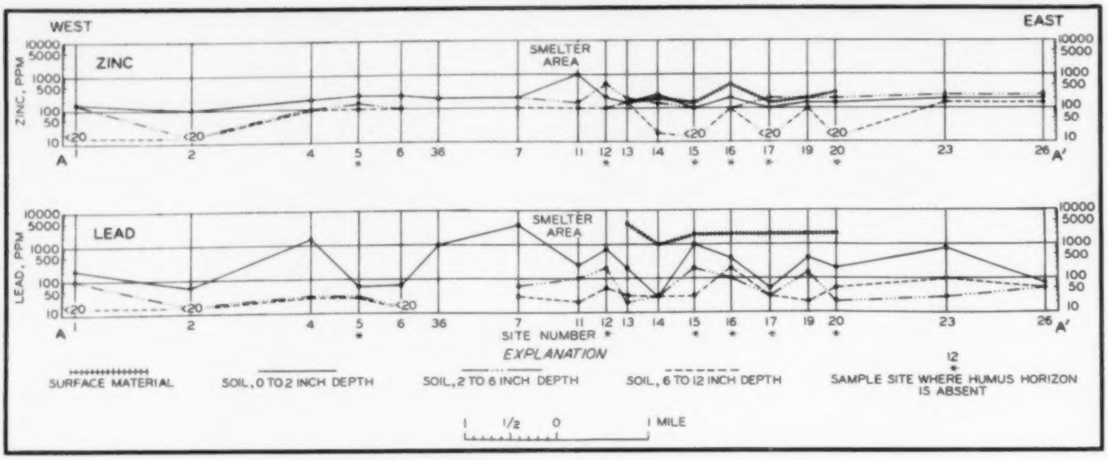


Fig. 3—Vertical distribution of metal along traverse AA′.

that passed through an 80 mesh sieve was used for all analyses.

RESULTS OF INVESTIGATIONS

The lead and zinc content of each soil sample is shown in Figs. 2 and 3 and in Table I. Fig. 2 presents the analytical data in a series of bar graphs to facilitate comparing the lead and zinc contents of the various sets of profile samples. Fig. 3 shows the vertical distribution of metal along traverse AA′.

Because these determinations were semi-quantitative, and the field work only reconnaissance, too much significance should not be given to small differences in metal content of the samples. Much more sampling and analysis would be needed, moreover, to account for both the horizontal and vertical distribution of metal contaminants as revealed by the data.

Lead and Zinc Contamination Patterns: Kennedy and Hobbs,[5] conducting the earlier program, collected soil samples in the vicinity of the sub-outcrops of many known veins, as well as beyond the periphery of the district known to be mineralized. On the basis of resulting data, they concluded that background values for copper, lead, and zinc in the Coeur d'Alene area are about 25, 20, and 100 ppm, respectively. It may be seen that by comparison many samples of the present writer's study contain highly anomalous quantities of both lead and zinc, but the distribution is somewhat erratic, both horizontally and vertically.

Actual distribution of metal along traverse AA′ bears only slight resemblance to an asymmetrical curve skewed to the east. In some locations there are wide differences in metal content of the samples, even between those from closely adjacent sites. There are several possible explanations for this discrepancy.

First, although it might be expected that the metal contaminants would be evenly spread over large tracts of ground, this may not be so. Owing to the funneling action of the topography in this area, there may be significant long-term variations in the intensity of fall-out at different localities.

Second, it is very probable that many of the irregularities are caused by differential erosion of the metal-rich surface layer, and by variations in the amount of metal filtering down into the soil owing to differences in soil porosity and permeability. In many portions of the barren zone around the smelter, as well as in outlying areas where most of the vegetative cover is gone, much of the soil is being actively eroded by sheet wash and deflation. In such areas any layer of metal contaminants probably would not be preserved to any extent. It is conceivable that at the bases and at topographic benches on these barren slopes, deposits of metal-rich colluvium have attained considerable thickness, perhaps accounting for the appreciable metal content, especially lead, of both the 0 to 2-in. and the 6-in. samples at sites 39, 40, and 41.

The contrast between lead profiles at sites 14 and 15 is a striking example of discrepancy possibly produced by differences in soil porosity and permeability. At site 14, in spite of a surface humus layer containing 0.1 pct Pb, there has been no contamination of the lower horizons, which contain only 30 ppm lead. At site 15, on the other hand, an appreciable amount of lead has been dispersed through the first 6 in. of the soil from a similar lead-rich surface layer. Both these sites, less than half a mile apart, are on slopes of about the same degree of steepness and have the same amount of vegetative cover. If only these two sites were considered, it could be postulated that at site 14, which has a humus horizon, the lead has been immobilized by formation of complex metallo-organic compounds, whereas at site 15 the lack of a humus horizon has prevented any complexing action. But this hypothesis is probably incorrect, as shown by the lead profiles at sites 17 and 19, where exactly the opposite situation prevails.

Another fact requiring explanation, if these differences are caused by variations in permeability, is the absence of any similarity between zinc and lead profiles at these sites. For example, at site 14 there has been appreciable downward migration of zinc, but almost no migration of lead. Looking at all the profiles in Fig. 3, the author believes that many of these apparent discrepancies are due to different dispersal mechanisms for lead and zinc in the soil profile. As a working hypothesis, he suggests that much of the zinc is dissolved out of the surface layer and migrates downward in solution, whereas most of the lead is carried down mechanically in suspension. This theory helps explain many of the distributional patterns, and it seems reasonable because the degree of mechanical

infiltration of lead particles should be much more dependent on soil porosity than is the diffusion of material carried in true solution. Of course, at those sites where the soil is very porous, much of the zinc, as well as the lead, may be moved mechanically in a suspension.

The rather low and uniform zinc content of the soil at most of the sites is worth noting. Most values are between 100 and 300 ppm. Only at sites 8, 9, 10, and 37, all in the immediate smelter area, do most of the samples contain highly anomalous amounts of zinc. At six of the sites along traverse AA', the low zinc values of the samples taken from 6 to 12 in. seem to show that the average zinc content of the terrace gravels is considerably under the 100 ppm that Kennedy and Hobbs consider normal for soils. But no correspondingly lower value is evident for lead. It may be that the 100-ppm zinc values for the 6 to 12-in. samples at such sites as 4, 5, and 6 merely indicate areas where there is somewhat more zinc than is average for soils developed on the terrace gravels, or, of course, these values may represent sites where zinc-bearing solutions had penetrated to greater than average depth in the profile. The similarity in zinc content of the surface samples, the 0 to 2-in. samples, and the 2 to 6-in. samples is probably due to the greater mobility of zinc; this is in striking contrast to the lead pattern, in which concentration usually falls off rapidly with depth. As shown by the profiles in Fig. 3, in nearly all instances the lead content of the surface material is considerably higher than that of the immediately underlying material, but there is little difference in the amount of zinc. At some sites, in fact, the top layer may have a slightly lower zinc content than the material immediately underlying, as is true along the eastern third of traverse AA'.

At two sites, 27 and 43, the fact that the lead content of the 6-in. samples exceeds that of the 0 to 2-in. samples suggests that mineralization near these sites may be contributing some metal to these samples.

It was surprising to find above-normal amounts of lead in the 6-in. samples taken at the outlying sites (Fig. 1, Table I). Only at site 45, at the mouth of Dexter Gulch, does the lead content of the 6-in. sample exceed the critical value for lead discussed later. The reason for these above-normal values is not known. It is worth pointing out, however, that site 46 is not far from an area that was sampled in detail by Kennedy and Hobbs and found to have only background quantities of lead in the soil over much of the locality.

The generally lower zinc values give the impression that fall-out intensity of zinc contaminants is considerably less than that of lead. The different mobilities of lead and zinc are undoubtedly responsible for this impression; as most of the zinc contamination is distributed through at least 6 in. of soil, there is no extremely high zinc value in any one section, whereas most of the lead is concentrated in the top 2 in. of the profile. To illustrate: suppose that 1500 ppm of lead and zinc are added to the top half-inch of a soil layer 6 in. thick with a normal lead and zinc content of 20 ppm and 100 ppm, respectively. Should the excess zinc in the surface layer be distributed evenly throughout the 6-in. layer, the zinc content would be increased from 100 ppm to only 200 ppm, whereas distribution of the excess lead through the upper 2 in. of this layer would increase the lead concentration from 20 ppm to about 300 ppm.

Discussion of Data: In evaluating the data contained in this report, it must be realized that the Coeur d'Alene district has been extensively mined and prospected since the early eighties, and the amount of metallic contamination at each site undoubtedly represents an integrated total of contaminants from more than one source. The geochemical data of Kennedy and Hobbs warrants a tentative conclusion that smelter fumes contributed most of the metal contaminants to the majority of samples collected for this study. Much of their geochemical work was done near Burke and Mullen, more than 15 miles from the smelter. Nearly all the samples they collected over unmineralized bedrock contained only background quantities of lead and zinc. As most of their samples were composites of the first 4 in. of soil directly underlying the humus horizon, any contamination would be reflected in the metal content of these samples. Presumably, since Kennedy and Hobbs sampled chiefly in active or previously active mining areas, their sites were as subject to contamination by windblown tailings and dump material as the sample sites selected by the writer. Therefore it is reasonable to assume that most of the contamination found in the present writer's investigation is due to smelter fumes.

Table I. Metal Content of Samples Collected from Outlying Sites Shown in Fig. 1

Depth, In.	Number of Samples	Percent of Samples in which Metal Content Exceeds: 100 Ppm Lead	200 Ppm Zinc
34	0 to 2	400	200
	6	70	50
44	0 to 2	400	250
	6	100	150
45	0 to 2	250	200
	6	150	150
46	0 to 2	250	100
	6	100	100

Table II. Summary of Data Presented in Table I and Fig. 2

Site Number	Sample Depth, In.	Parts Per Million: Lead	Zinc
0 to 2	45	67	38
2 to 6, 6	46	24	24
6 to 12	22	5	14

Effect of Contamination on Geochemical Soil Surveys: Before the effect of contamination on any geochemical soil survey can be appraised, it is necessary to determine what contamination level is critical. Widespread, fairly even contamination of an area will raise the local background; the difficulty of prospecting will increase as contamination increases, with no real critical points. Very spotty contamination, on the other hand, does have a critical value; it is that amount of metal which, added to a background sample, will raise the concentration above the threshold value. The threshold value, as defined by Hawkes (Ref. 6, p. 338) is the limiting anomalous value below which variations represent only normal background effects, and above which they are significant in terms of possible mineral deposits.

The data of this survey show that in the Coeur d'Alene district the contaminants are distributed somewhat erratically; therefore it would seem that in this area the greatest danger from contamination to geochemical soil surveys is the presence of spurious anomalies. For an estimate of how much lead and zinc would have to be added to soil of background composition to create such a spurious anomaly, the threshold values for these metals must be known. The data of Kennedy and Hobbs on soils collected in mineralized areas show that near 11 of the 13 veins they studied, lead is concentrated above background to a much greater extent than zinc. The ratio of highest lead concentration to background ranged from 20 to as much as 1500. The zinc content was much less satisfactory—at only two veins did the zinc content exceed six times the background value. As the lead anomalies generally show a substantially higher contrast to the background, Kennedy and Hobbs concluded that lead is the best element to use when prospecting for orebodies expected to contain much lead and zinc, and that analyses for zinc would be useful primarily in searching for ore where the zinc-lead ratio would probably be high. They believe that soil samples should be considered probably anomalous if the metal concentration is two to four times the normal concentration, and almost certainly anomalous if the concentration is more than four times background.

Considering lead first, it seemed that 100 ppm would be a conservative threshold value. Although 100 ppm is five times the background value (20 ppm) and therefore falls just past the limit of the "probably anomalous" range of Kennedy and Hobbs, in view of the large contrast for lead over most ore zones, lead values of 100 ppm or under would probably not be taken very seriously. Even if the lead background were raised to 100 ppm, the 11 lead anomalies of Kennedy and Hobbs would still be very striking in their contrast to this higher background.

The effect of zinc contamination on geochemical prospecting in this district is not so critical where lead has been found the more valuable indicator in locating ore. The lowest threshold of practical application in geochemical prospecting is about twice the background value. For zinc, therefore, the threshold value was set at 200 ppm, twice the average background value. This figure, which gives a lower ratio than was used for lead, was selected because near most of the veins studied by Kennedy and Hobbs zinc is not concentrated in amounts above background to the extent that lead is, and also because it would take only a slight increase in the zinc background to submerge many of the very weak zinc anomalies completely. Soil analyses over two veins that did contain appreciable amounts of zinc yielded satisfactory contrasts—at one site the ratio of the highest zinc concentration to background was 15; at the other, 36. It should be emphasized again, however, that as most of the veins contain a high lead-to-zinc ratio—at least near the surface—it is unlikely that analysis would be made only for zinc.

It is suggested, then, that at the depth sampled, contamination by more than 80 ppm lead and 100 ppm zinc would raise the lead and zinc content above the threshold values and might make it difficult to interpret soil survey data. Evaluation can best be accomplished by referring to Table II, which summarizes the data of Fig. 2 and Table I. It must be admitted that a somewhat lower threshold value for zinc should be probably used for those sites located on the terrace gravels, since the zinc background of soils developed on this material is probably lower; even had this been done, however, the figures in Table II would not have been changed appreciably.

The data in Table II indicate that within the area studied the upper 6 in. of soil should not be sampled in any geochemical soil survey, as there are probably excessive amounts of lead and zinc contaminants that would raise the metal content of the samples above the limiting threshold values, thereby creating spurious anomalies. The data strongly suggest that below 6 in. serious contamination is so rare that the metal content of the soil samples taken below this depth could be used with confidence in prospecting for concealed mineral deposits. It should be emphasized, however, that these findings are specific for this district and it would be hazardous to attempt to extrapolate them to other districts.

CONCLUSIONS AND RECOMMENDATIONS

Results of this survey indicate that the degree of contamination below about 6 in. is not enough to interfere seriously with geochemical prospecting techniques in this area. Some samples taken below this depth (especially in the immediate vicinity of the smelters and in very loose-textured soils) may be contaminated to some extent, particularly with zinc, because of its greater mobility. But it seems unlikely that an occasional contaminated sample would seriously interfere with interpretation of data, since a geochemical anomaly is rarely indicated by a single high sample.

To be on the safe side, however, it would be wise to collect all samples in this area from a depth of at least 10 in., although this may be difficult in the rocky soil of certain sections. It is important to prevent any soil above this depth from mixing with the sample, particularly surface material, which is extensively contaminated, especially with lead. Because there are not enough data from this survey to delimit completely the area of badly contaminated ground, no distance can be given beyond which contamination would not have to be considered; however, the 10-in. depth is highly recommended within at least a five-mile radius of the smelter area. Beyond this distance, suitable orientation sampling should be done if there is any question at all about the presence of contamination.

Results of the Kennedy and Hobbs study to date were generously made available to the author, who has indicated at appropriate places in the text where this information was utilized.

Publication of this article has been authorized by the Director, U. S. Geological Survey.

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GRAVITY METHODS CLEAN EXTREME FINE SIZES OF BITUMINOUS COAL

Low-cost recovery and simple operation, with reduced ash and sulfur content in the yield of clean coal.

by H. B. CHARMBURY and D. R. MITCHELL

Recovery of fine coal from solids reporting to wash water has become increasingly important. These solids range from about 28 mesh to 0 and constitute 3 to 7 pct by weight of the feed tonnage to a coal preparation plant. In the past they were usually wasted to streams, but present clean stream legislation makes it necessary to remove them from the wash water and, if economically possible, recover the associated coal as a saleable product.

Where these solids are not wasted to streams or to slime ponds they are recovered by thickeners and filters. Since filter cake is often high in ash or sulfur, or both, it is not readily marketed or used. Common practice is to mix it with other plant products, generally slack or cleaned run-of-mine. Uniform blending is difficult, not only because the impurity is usually high, but also because during certain operating periods it is possible to get a concentration of this filter cake in a railroad or barge.

At some plants filter cake has been derived from the froth flotation clean-up of Dorr thickener underflow. The operating circuits required for a froth flotation plant make this a comparatively high-cost treatment, and in the last few years experiments have been carried out with bulk oil methods. These also are quite expensive and lend themselves only to special situations.

Table I gives some characteristics of thickener underflows for plants in the Pittsburgh area treating Pittsburgh seam coal. It will be noted that there is a concentration of impurities in the -200 mesh sizes.

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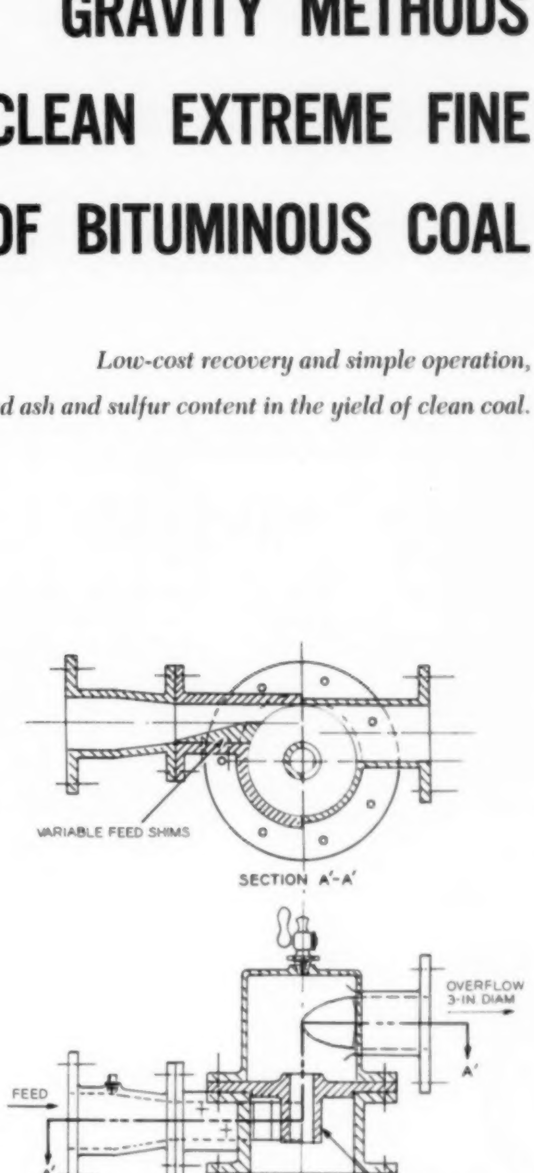

Fig. 1—The 6-in. Dorrclone for A and B samples.

Table I. Size, Ash, and Sulfur Analysis for Thickener Underflows

Mesh		Direct			Cumulative Retained		
Passing	Retained	Wt, Pct	Ash, Pct	S, Pct	Wt, Pct	Ash, Pct	S, Pct
			Plant A				
	48	13.2	7.8	1.46	13.2	7.8	1.46
48	100	45.4	6.0	1.52	58.6	6.4	1.51
100	200	23.5	18.3	2.76	82.1	9.8	1.87
200	325	14.3	34.2	5.37	96.4	13.4	2.39
325		3.6	40.1	6.44	100.0	14.4	2.53
			Plant B				
	48	20.0	6.1	1.40	20.0	6.1	1.40
48	100	22.7	6.6	1.46	42.7	6.4	1.43
100	200	24.5	14.8	2.36	67.2	9.4	1.77
200		32.8	41.8	2.52	100.0	20.1	2.02
			Plant C				
	48	17.7	8.0	1.65	17.7	8.0	1.65
48	100	24.5	10.5	1.87	42.2	9.5	1.78
100	200	20.7	19.1	2.63	62.9	12.7	2.06
200	325	17.3	27.2	2.30	80.2	15.8	2.11
325		19.8	43.7	2.27	100.0	21.3	2.14

Table II. Washability Data for +200 Mesh Fraction Thickener Underflow, Plant C

−200 mesh — 62.9 Pct—11.1 Pct Ash—2.02 Pct S
+200 mesh — 37.1 Pct—39.0 Pct Ash—2.21 Pct S
Head Analysis—100.0 Pct—21.3 Pct Ash—2.14 Pct S

Specific Gravity		Direct			Cumulative Float		
Sink	Float	Wt, Pct	Ash, Pct	S, Pct	Wt, Pct	Ash, Pct	S, Pct
	1.30	84.4	4.2	1.23	84.4	4.2	1.23
1.30	1.40	2.5	16.0	2.40	86.9	4.5	1.27
1.40	1.50	1.7	22.7	3.06	88.6	4.8	1.30
1.50	1.60	2.3	24.4	3.52	90.9	5.3	1.36
1.60	1.70	1.3	35.5	4.54	92.2	6.8	1.40
1.70		7.8	75.0	9.34	100.0	11.1	2.02

Table III. Results of Cleaning Thickener Underflow Material from Plant *A* in a 6-In. Cyclone

Conditions	Feed Inlet to Cyclone	Clean Coal Overflow Product	Refuse Underflow Product
Pulp, gpm	69.4	54.1	15.3
Solids, tph	10.8	5.9	4.9
Solids in pulp, pct	32.2	30.5	56.2
Total solids, pct	100.0	54.7	45.3
Ash in solids, pct	13.6	10.8	16.9
Sulfur in solids, pct	2.24	1.66	2.93

Table V. Results of Cleaning Thickener Underflow Material from Plant *B* in a 6-In. Cyclone

Conditions	Feed Inlet to Cyclone	Clean Coal Overflow Product	Refuse Underflow Product
Pulp, gpm	73.1	59.3	14.8
Solids, tph	8.45	5.89	2.56
Solids in pulp, pct	40.4	35.6	56.3
Total solids, pct	100.0	70.0	30.0
Ash in solids, pct	19.3	17.5	23.4
Sulfur in solids, pct	2.02	1.66	2.83

Table VII. Results of Gravity Belt Test with Thickener Underflow Material from Preparation Plant C

Product	Wt, Pct	Ash, Pct	Ash Distribution, Pct	S, Pct	Sulfur Distribution, Pct
Clean coal	88.2	19.2	77.5	1.65	70.5
Refuse	11.8	42.3	22.5	5.18	29.5
Calc. head	100.0	21.9	100.0	2.07	100.0

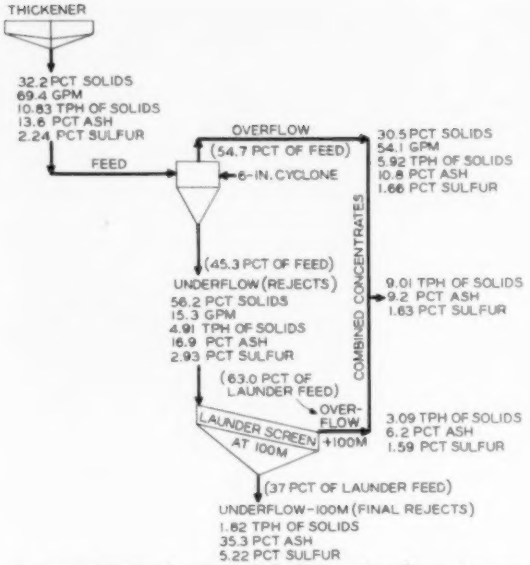

Fig. 2—Proposed material balance flowsheet for preparing clean coal from Plant A thickner underflow.

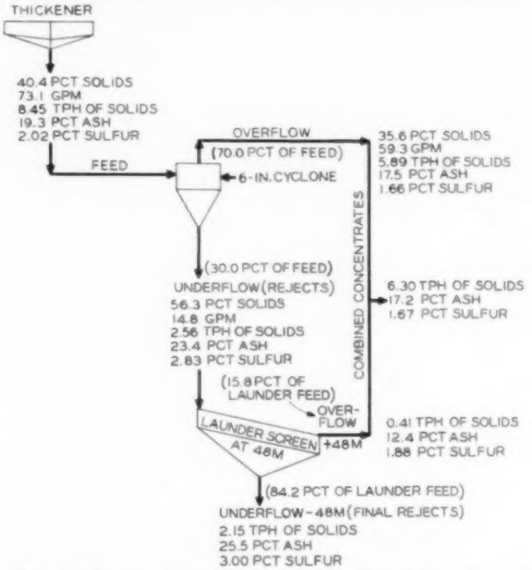

Fig. 3—Proposed material balance flowsheet for preparing clean coal from Plant B thickner underflow.

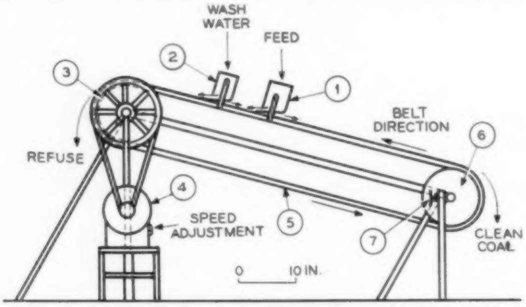

Fig. 4—Gravity belt separator used for plant C product. Legend: 1) feed box; 2) wash water box; 3) drive or head end; 4) variable speed motor; 5) waffle-grid, belt, ⅛-in. pockets; 6) tail end; and 7) separator slope adjustment.

Development of the launder screen, particularly in the anthracite region, has made it economically possible to do a partial cleaning job on fines of this character by sizing on the screen. With this type of screen, size separation is held to a lower limit of about 100 mesh, with coal loss, of course, in the undersize.

In recent years slimes have been effectively removed by low-pressure cyclones, which are economically sound for those plants where an underflow product of marketable grade can be obtained. The possibility of using high-pressure cyclones as concentrators for cleaning Dorr thickener underflow has been under investigation in the mineral dressing laboratories of The Pennsylvania State University for some time. Results have been encouraging, and at least one plant installation has been made for this purpose and is now operating. The laboratory has also developed a gravity method of separation that utilizes stream flow action on a specially designed traveling belt machine. These two units, cyclones and gravity belt separators, have proved effective in removing sulfur from Dorr thickener underflows, so that it is possible to obtain a low sulfur product suitable for blending with other products of the preparation plant. This is particularly important to plants preparing coal for metallurgical purposes.

Coals Investigated: The coals used in these tests were obtained from slurry samples taken as thickener underflows from three preparation plants in the Pittsburgh area of Pennsylvania. These coals, which vary from 2.02 to 2.53 pct sulfur and 14.4 to 21.3 pct ash, represented an enormous quantity of marketable material if the ash content could be reduced and, more particularly, if the sulfur content could be lowered below 1.70 pct.

Table I shows the size, ash, and sulfur analyses of the coals from the three different preparation plants, *A*, *B*, and *C*. Calculations of the cumulative oversize indicate that specification grades of less than 1.70 pct sulfur may be attained by sizing. If samples *A* and *B* were separated at some size in the range of 100 to 200 mesh, specification grade clean coal with less than 1.70 pct sulfur could be obtained. The ash content of the coal from plant *A* would be lowered from 20.1 to less than 9.0 pct. Recoveries, in these cases, would range from 60 to 70 pct.

The sample from plant C, however, would have to be sized at about 48 mesh to meet specification grade. In this instance the ash would be lowered from 21.3 to 8.0 pct, but clean coal recovery would amount to only 17.7 pct of the total coal.

Table II lists washability data on the +200 mesh fraction of thickener underflow material from plant C. Calculations using these data indicate that cleaning only the +200 mesh material at a gravity of 1.70 will increase recovery from the 17.7 pct shown above to 58.0 pct (62.9 x 0.922). In this case sulfur would be lowered from 2.14 to 1.40 pct and ash from 21.3 to 6.8 pct. Also, should the −200 mesh fraction representing 37.1 pct of the coal and having 39.0 pct ash and 2.2 pct sulfur be blended into the clean portion of the +200 mesh obtained at a gravity of 1.50, a clean coal with less than 1.65 pct sulfur and 18.5 pct ash could be produced and recovery could be raised to 92.8 pct. Thus the combination of sizing and gravity concentration with reasonable recovery to meet specification grade appears theoretically possible and attractive.

Cyclone Tests with Samples A and B: Details of the 6-in. diam cyclone used in this work are presented in Fig. 1. The feed inlet opening to the

Table IV. Size, Ash, and Sulfur Analyses of Cyclone Products from Plant *A* Slurry

Mesh		Direct			Cumulative Retained			Cumulative Passing		
Passing	Retained	Wt, Pct	Ash, Pct	S, Pct	Wt, Pct	Ash, Pct	S, Pct	Wt, Pct	Ash, Pct	S, Pct
				Clean Coal Overflow Product 54.7 Pct of Feed						
	48	9.6	10.0	1.27	9.6	10.0	1.27	100.0	10.8	1.66
48	65	18.6	4.8	1.38	28.2	6.6	1.34	90.4	10.9	1.70
65	100	26.8	6.4	1.45	55.0	6.5	1.40	71.8	12.5	1.79
100	200	24.8	9.3	1.66	79.8	7.4	1.48	45.0	16.1	1.99
200	325	16.6	23.2	2.36	96.4	10.1	1.63	20.2	24.5	2.39
325		3.6	30.2	2.54	100.0	10.8	1.66	3.6	30.2	2.54
				Refuse Underflow Product 45.3 Pct of Feed						
	48	17.2	6.1	1.44	17.2	6.1	1.44	100.0	16.9	2.93
48	65	20.5	5.2	1.50	37.7	5.6	1.47	82.8	19.2	3.24
65	100	25.3	7.0	1.76	63.0	6.2	1.59	62.3	23.8	3.82
100	200	22.2	28.2	2.86	85.2	11.9	1.92	37.0	35.3	5.22
200	325	11.9	44.9	8.39	97.1	15.9	2.71	14.8	45.9	8.77
325		2.9	50.0	10.34	100.0	16.9	2.93	2.9	50.0	10.34

Table VI. Size, Ash, and Sulfur Analyses of Cyclone Products from Plant *B* Slurry

Mesh		Direct			Cumulative Retained			Cumulative Passing		
Passing	Retained	Wt, Pct	Ash, Pct	S, Pct	Wt, Pct	Ash, Pct	S, Pct	Wt, Pct	Ash, Pct	S, Pct
				Clean Coal Overflow Product 70.0 Pct of Feed						
	48	10.1	4.5	1.28	10.1	4.5	1.28	100.0	17.5	1.66
48	100	25.0	5.6	1.31	35.1	5.3	1.30	89.9	19.0	1.70
100	200	22.8	8.6	1.58	57.9	6.6	1.41	64.9	24.2	1.85
200		42.1	32.6	2.00	100.0	17.5	1.66	42.1	32.6	2.00
				Refuse Underflow Product 30.0 Pct of Feed						
	48	15.8	12.4	1.88	15.8	12.4	1.88	100.0	23.4	2.83
48	100	24.9	15.2	2.14	40.7	14.1	2.04	84.2	25.5	3.00
100	200	24.2	17.5	3.16	64.9	15.4	2.46	59.3	29.8	3.37
200		35.1	38.3	3.51	100.0	23.4	2.83	35.1	38.3	3.51

cylindrical part of the cyclone was 1½ in. square. Vortex diameter was 2½ in. and overflow outlet diameter 3 in. Underflow was discharged through a ⅝-in. diam orifice.

Plant *A* thickener underflow containing 32.2 pct solids was pumped into the cyclone at 69.4 gpm at 40-psi inlet pressure. Details of the sample to the cyclone and the clean coal and refuse products from the cyclone are presented in Table III. From these results it may be seen that the clean coal met specification grade with 1.66 pct sulfur and that ash was reduced from 13.6 to 10.8 pct. Recovery of clean coal was 54.7 pct.

The size, ash, and sulfur analyses of the overflow and underflow products are presented in Table IV. From these results it appears that, under the conditions tested, the cyclone acted as a concentrating unit rather than as a classifier. It may also be seen that if the underflow were sized at 100 mesh, more specification grade material could be recovered and overall recovery of the clean coal with less than 1.65 pct sulfur could be raised to 83.2 pct. Fig. 2, based on the above results, is the proposed flowsheet for recovering specification grade clean coal from thickener underflow fines from preparation plant *A*.

Similar results of a cyclone test with the thickener underflow material from preparation plant *B* are presented in Tables V and VI and Fig. 3. From these results it may be seen that a clean coal with 1.66 pct sulfur and 17.5 pct ash was obtained from a feed to the cyclone with 2.02 pct sulfur and 19.3 pct ash. Clean coal recovery in this test was about 70 pct. Sizing the underflow material from the cyclone at 48 mesh raised recovery to 74.6 pct.

In the above cases the cyclone acted as a concentrator rather than as a sizing classifier because inlet pressures and specific gravities of the inlet suspension were relatively high. The high inlet pressures resulted in greater centrifugal force to throw the particles to the periphery of the cylindrical section, and the high percentage of solids created a barrier on the periphery, forcing the lighter coal particles into the center and the heavier refuse particles to the outside.

Other factors of importance in this type of cyclone operation were the vortex and underflow diameters. These were adjusted so that some 80 pct of the pulp reported in the overflow and about 20 pct in the underflow.

It is to be noted that the high-pressure cyclone is particularly effective in concentrating sulfur in the underflow. This is undoubtedly due to the higher specific gravity of pyrite compared to slate and coal and is especially important at metallurgical coal plants. Usually a relatively high ash filter cake product can be mixed in with the overall plant product, but not a high sulfur filter cake. Also, since the cyclone can be operated on straight thickener underflows without added water, processing by the cyclone method is much simpler than by other methods requiring large quantities of water.

The attrition effect in pumps and in the cyclone tends to free coal particles from impurities and gives recoveries higher than indicated by sizing and sink-float tests of the feed. Tests are projected to determine the effect of closer sizing or classification on results that might be obtained on processing thickener underflows in high-pressure cyclones.

Gravity Belt Test with Sample C: Since the thickener underflow product from preparation plant *C* had a size consist and analysis entirely different from the products of plants *A* and *B*, a different method of concentration was investigated. Washability data on the plant *C* product indicated that gravity concentration was feasible.

The apparatus used for concentration was the gravity belt separator illustrated in Fig. 4. This is a continuous belt separator set at a slope, with the belt traveling uphill. This rectangular belt is 5 in. wide and 1 in. deep and has a waffle-type surface with ⅛-in. cubes. Other waffle-type surfaces are available.

Feed suspension flows by gravity through a ¾-in. hose into a feed box over the belt center, giving an even distribution of pulp across the width of the belt, which travels counter to the flow. Heavy refuse particles are trapped in the waffles, carried over the top of the belt, and washed with spray water into a launder; the lighter clean coal particles flow over the belt and are discharged at the lower end. Upstream from the feed, provisions are made to dilute the original pulp with water from a box similar to the feed box.

Operation variables are slope, belt speed, feed flow rate, density, and amount of wash water. An increase in slope increases the yield of clean coal but also raises the percent sulfur. Greater belt speed decreases the yield with very little change in percent sulfur. Faster flow rate rapidly increases recovery of clean coal but usually sacrifices cleanliness of products. The percent sulfur in the clean coal rises with increased flow rate, particularly at the higher rates. Changes in feed pulp density have very little effect on the recovery or grade of clean coal. Increases in pulp density do slightly increase the percent sulfur in the refuse. The use of wash water increases recovery of clean coal but also the percent sulfur in the clean coal. It also increases sulfur in the refuse.

As a result of these findings, tests were conducted with thickener underflow material from plant *C*, using a slope of 9°, belt speed of 6.5 fpm, and a pulp rate of about 1 gpm with 17 pct solids. No wash water was used during the test. Results under these conditions (Table IV) show a clean coal recovery of 88.2 pct with specification grade sulfur. Sizing and washability data indicated a theoretical recovery of 92.8 pct with 1.65 pct sulfur. Theoretical data also indicated 18.5 pct ash with this sulfur value. The belt test showed an ash reduction from 21.9 pct in the feed to 19.2 pct in the clean coal. This indicates that the belt was removing mainly the heavy particles, such as pyrite, in the refuse.

Further reductions in sulfur content of the clean coal were made by passing the clean coal product from the first test over the belt a second time, which produced a recleaned coal and middling product in addition to the refuse. Conditions were the same for test No. 2, except that pulp density was reduced to 15 pct solids. The second test showed reduction of sulfur to 1.54 pct, with a clean recovery reduction to 79.4 pct. The middling product amounted to 8.8 pct of the total feed and contained 34.1 pct ash and 2.51 pct sulfur.

A number of tests were made on this traveling belt separator. At optimum conditions it proved an effective machine for removing fine pyritic sulfur from thickener underflows. The machine is easy to construct, and in normal plant operation maintenance cost would be low.

Discussion of this article sent (2 copies) to AIME before March 31, 1959, will be published in MINING ENGINEERING.

SUBSURFACE INVESTIGATIONS OF A PLANT SITE

by LeROY SCHARON, ROBERT UHLEY, and TSVI MEIDAV

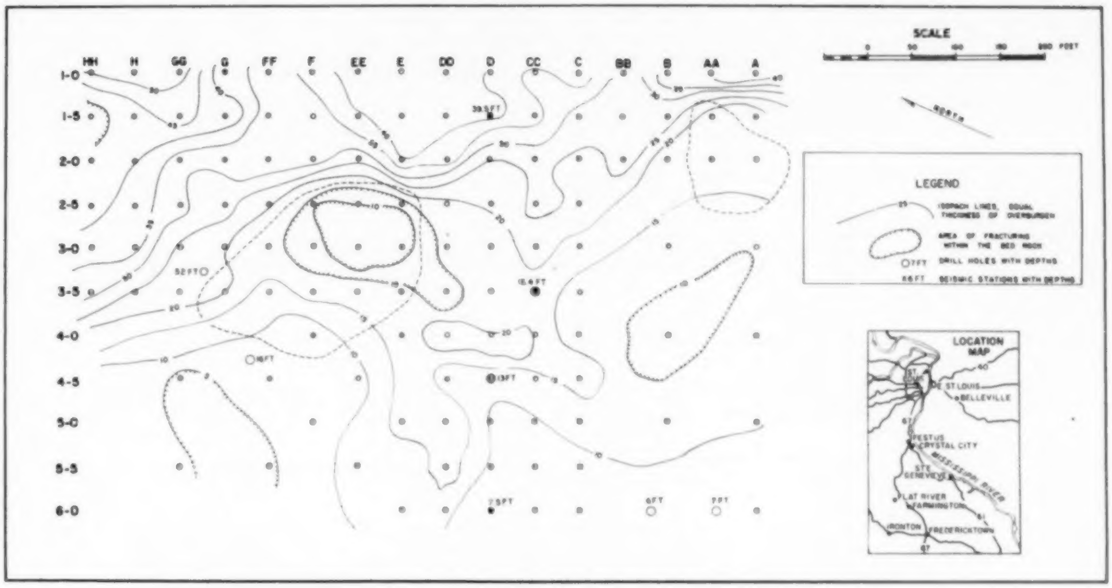

Fig. 1—Isopach map of overburden showing areas of deeply fractured bedrock.

Before National Lead built an industrial plant on its Fredricktown property, some 100 miles south of St. Louis, a 750x500-ft area on the proposed site was investigated by electrical resistivity, seismic refraction, and churn drilling. Data were accumulated to prepare an isopach map of the overburden and to determine soundness of the dolomite bedrock and the depth to bedrock at fixed points.

The site was on a gently sloping hillside. Elevations above sea level ranged from 760 ft in the northwest corner to 820 ft along the eastern edge, giving a total relief of 60 ft. There were no major drainage features, but in the northern part of the plant site there was an indicated depression area which later was interpreted as reflecting subsurface conditions in the bedrock. No rock was exposed in the entire plant site area; the surface was characterized by soil and overburden.

GEOLOGY

Prevailing geology in the area of investigation was relatively simple—Bonneterre dolomite overlain by residuum. The red overburden was that derived from the weathered Bonneterre. Some chert was present, interpreted in the general area as a weathering of both the Bonneterre dolomite and younger sedimentary rocks such as the Potosi dolomite. During the period of actual measurements the residuum varied from moist near surface on the western edge of the proposed site to dry near surface on the eastern edge, and for this reason overburden resistivities ranged from low on the west to high on the east. Seismic velocities were low, since the material was not well packed.

The bedrock encountered was dolomite, specifically the Bonneterre of Upper Cambrian age which, according to McQueen,[1] consists of an upper dark gray member and a lower light gray member. These have been further divided into four zones, in ascending sequence a dark gray, sandy argillaceous dolomite; a dark brown or black, fine-grained dolomite; a light gray, finely crystalline, compact dolomite; and, at the top, a dark brown, finely crystalline, compact dolomite. In the area of investigation the upper two zones were encountered in the drilling tests as constituting the bedrock. The dolomite varies widely in porosity, which is low in the dense, fine-grained layers. In this area, therefore, both electrical resistivities and seismic velocities were high.

Fracture zones in the Bonneterre are nearly vertical and may extend to some depth, causing considerable deep weathering. It was realized that over deep fracturing the apparent resistivities

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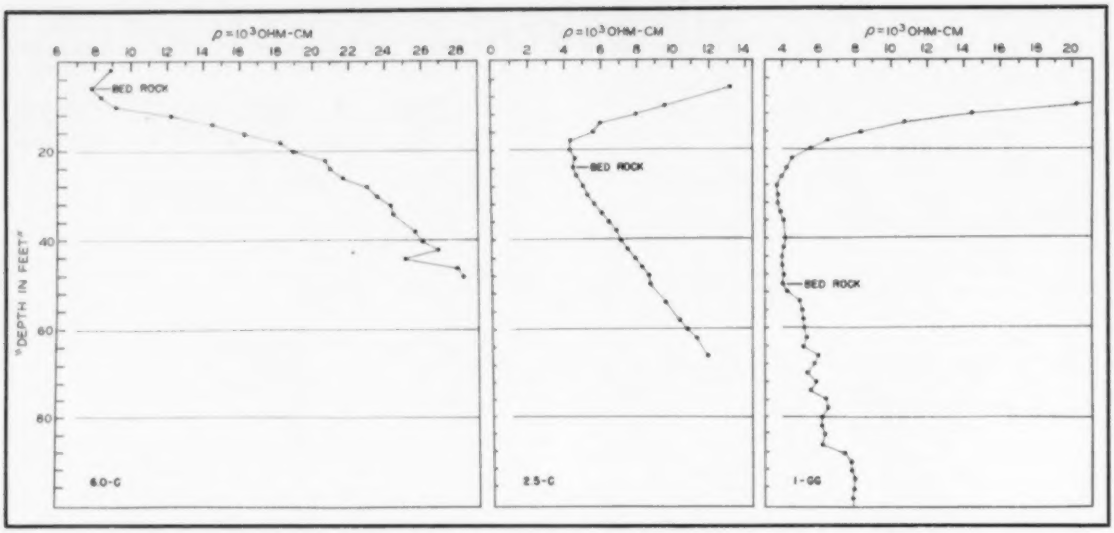

Fig. 2—Correlation chart showing increase in depth to bedrock from west to east in the area.

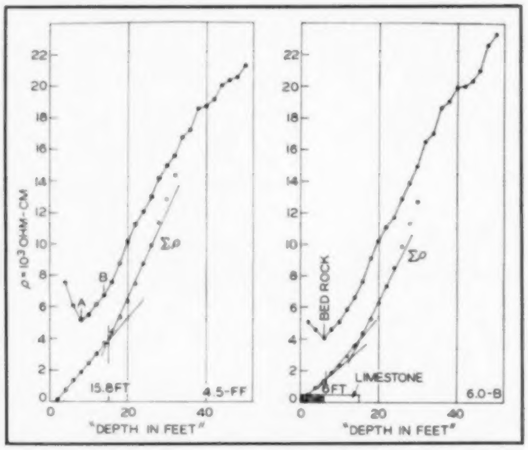

Fig. 3—Results of Moore method at 4.5-FF and 6.0-B.

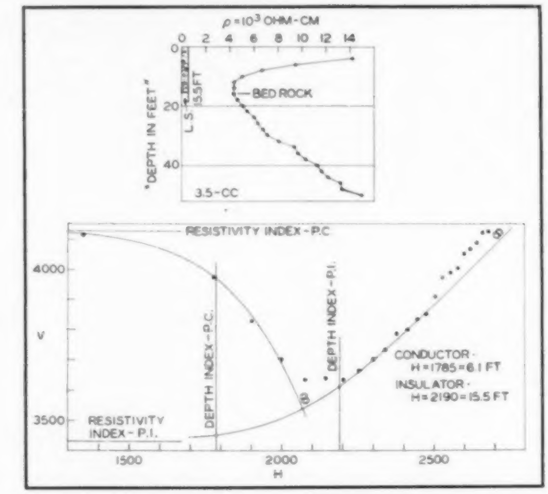

Fig. 4—Roman superposition results for station 3.5-CC.

would be extremely low, owing to the presence of mineralized waters and clays, and it was believed important to the investigation to recognize and outline such conditions.

Two holes were drilled in the plant site area, one at 4.5-D and the other at 3.5-CC. Data were available from four previous holes, but locations and information were considered doubtful. Reportedly they were 15 ft west of 6.0-B, 45 ft west of 6.0-A, 25 ft northwest of 4.5-FF, and near stations 3.0-GG and 3.5-G. All four yielded data indicating bedrock to be the Bonneterre dolomite with a clay and chert residuum.

GEOPHYSICS

Electrical resistivity was measured with equipment of the Gish-Rooney type[2] according to the Wenner[3] electrode configuration. At 124 stations, located on 50 and 100-ft centers (Fig. 1), profiles were measured by an interval of $a = 2$ ft to depths of 50 to 100 ft. Ten working days were required to make those measurements and determine the elevations at each station.

Following preliminary interpretation of the electrical data, shallow seismic refraction measurements were made at three points: 1) shallow depth to bedrock at 6.0-D, 2) medium depth to bedrock at 3.5-CC, and deep bedrock at 1.5-D. The seismic work was completed in less than a day.

Results: The aims of the subsurface investigation were readily met by combining results of the two types of geophysics and the check drilling. Compiled as an isopach map of the overburden, these results are given in Fig. 1, which shows the seismic stations and drillholes and their indicated depth to bedrock. Two areas of highly fractured zones in the bedrock are presented, one centered at coordinate 2.0-AA and the other at 3.5-F.

Interpretation of Electrical Data: When all the electrical resistivity depth profiles for the survey were assembled, one fact about depth to bedrock was revealed—it increased from the west to the east side of the area. The correlation of three profiles (6.0-C, 2.5-C, and 1.0-GG) in Fig. 2 shows that as depth to bedrock increases there is a marked change in apparent resistivities of the dolomite.

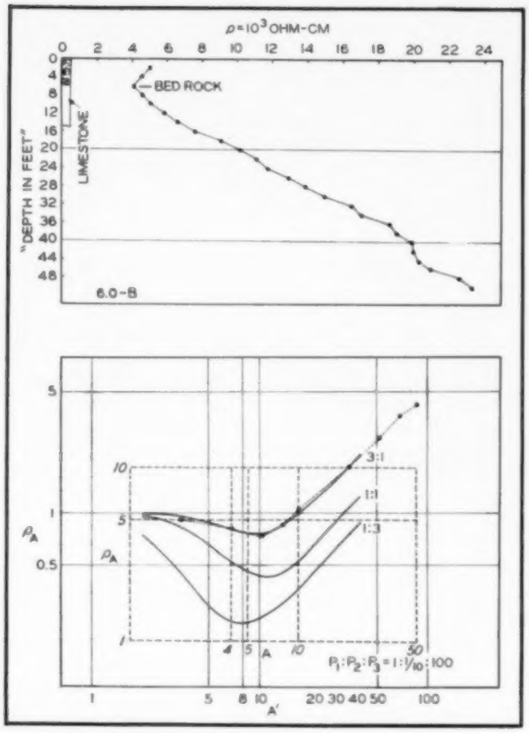

Fig. 5—Wetzel-McMurry interpretation for station 6.0-B.

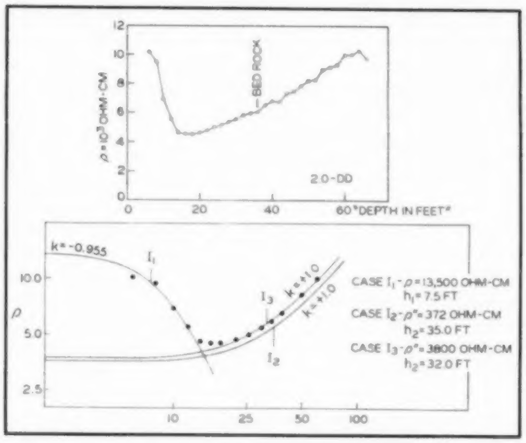

Fig. 6—Successive interpretation for station 2.00-DD.

Overburden resistivities, also given on this map, are directly associated with surface moisture content at the various elevations. At lowest elevation the resistivities are low; at maximum elevation they are very high.

Cumulative Resistivities: For most of the profiles the unknown depths to bedrock could be calculated from those already known, and early interpretations of electrical data seemed fairly straightforward because of the extreme contrast in resistivities between dolomite bedrock and residuum. But when the seismic refraction and drilling results became available, they pointed up the need for more precise interpretations. Depth to bedrock at station 4.5-FF was originally interpreted as 8 ft (break A, Fig. 3), while a drillhole 25 ft northwest of this station indicated dolomite at 16 ft. Because of the resistivity contrast, it was believed that point A was the depth to dolomite. A cumulative resistivity profile after Moore's method,[4] however, showed the break at point B, or a depth of 15.8 ft. To test the validity of this method still further, cumulative resistivity data were made for station 6.0-B (Fig. 4), where a drill check gave bedrock at a depth of 6 ft. A good resistivity break occurs on both the apparent and summation apparent resistivity curves at 6 ft. After all profiles of the general character of 4.5-FF and 6.0-B had been analyzed by the Moore method, it was concluded that this method can be applied only to profiles having a definite character. Mooney[5] has described the limitations of Moore's approach.

Roman Superposition Method: When the Moore analysis proved unsuitable for these data, they were interpreted by theoretical procedures. The following application of Roman's superposition method[6] is summarized in Fig. 4:

At station 3.5-CC both seismic and drilling checks were made, giving a calculated depth of 15.5 ft and 15.33 ft, respectively. Depth to the perfect insulator was calculated to be 15.5 ft—a very close agreement with seismic and drilling results. Since it was possible to correlate a portion of the resistivity curve with the "Reference Chart for Buried Conductors," depth to the perfect conductor was found to be 6.1 ft, which may be a reflection of the top of the water table.

Wetzel-McMurry Standard Curves: The Wetzel-McMurry set of standard apparent resistivity curves[7] for the three-layer case, using the Wenner electrode configuration, were matched with the field curves obtained. Typical results are given in Fig. 5, in which the original curve for station 6.0-B is superposed on a set of standard curves. The standards have the ratios for the three layers $\rho_1:\rho_2:\rho_3 = 1:1/10:100$, with h_2 (thickness of overburden) equal to 8 units on the standards. It will be seen that the number 8 on the standard curves corresponds to a, equal to 4.7 ft. This is the interpreted depth to bedrock. At this station, as indicated in Fig. 6, a drillhole available for checking purposes gave bedrock at 6 ft. Apparently depth to bedrock is more precise on the original field curve.

Successive Approximation Method: Hummel[8] has shown that a three-layer case may be solved by combining the thickness and resistivities of the upper two layers, using Kirchoff's Law:

$$\frac{d_1 + d_2}{\rho''} = \frac{d_1}{\rho_1} + \frac{d_2}{\rho_2}$$

where ρ_1 and ρ_2 are resistivities; d_1 and d_2 are thicknesses of the first and second layers, respectively; and ρ'' is the composite resistivity of the two layers. The solution for the third layer is found by using Roman's two-layer case. Watson and Johnson[9] and Spicer[10] have demonstrated that under favorable conditions this technique can be applied to the multi-layer case.

Analysis of the apparent resistivity profile at station 2.0-DD (Fig. 6) gives the application of this technique. First a Roman two-layer curve (I_1) was matched with the shallow part of the field profile, giving a value of $k = -0.96$, depth of h_1 as 7.5 ft, and ρ_1 equal to 13,500 ohm cms. When the resistivity ρ_2 was computed in the following equation, it was found to equal 311 ohm cms:

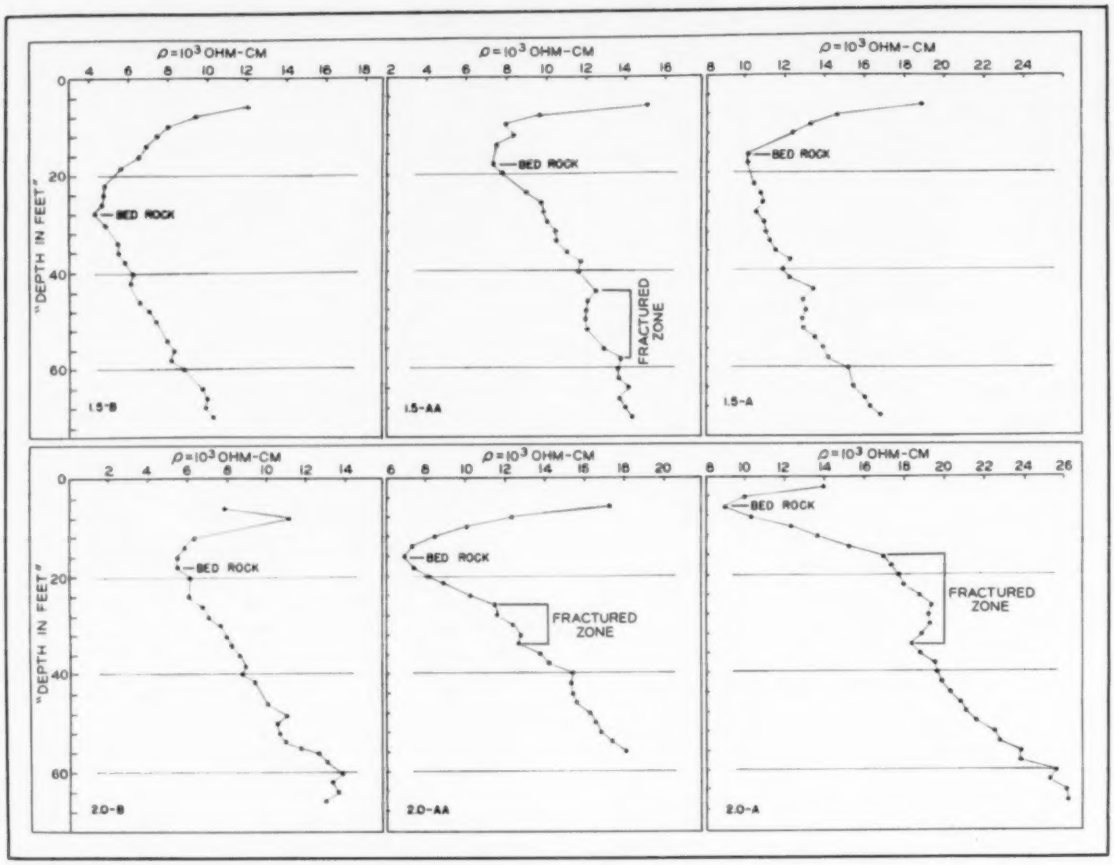

Fig. 7—Correlation chart showing method of delineating fractured zones in bedrock.

$$\rho_2 = \rho_1 \left(\frac{1 + k_1}{1 - k_1} \right) =$$

$$13{,}500 \left(\frac{1 - 0.955}{1 + 0.955} \right) = 311 \text{ ohm cms}$$

To determine the composite resistivity (ρ'') of the first two layers it is necessary to know the thickness of the second layer, d_2. This is approximated by applying Roman's two-layer curves to the deeper part of the field profile. In this operation h_2, the total depth to the bottom of the second layer, was found to be 35 ft; d_2 was then equal to 27.5 ft. Using Kirchoff's Law, the composite resistivity is computed as 372 ohm cms. The master curve is then superposed on the field curve with depth and resistivity indices corresponding to 35 ft and 372 ohm cms respectively, as shown by curve I_2. It is obvious that this fit is incorrect. A much better match can be obtained, however, by shifting the curve horizontally to the left. Correspondingly, the depth index shifts to 32 ft, and recomputing with the new d_2 gives ρ'' a value of 3800 ohm cms. When the new depth and resistivity indices are matched a better fit is obtained, as shown by curve I_3. The interpreted depth to bedrock in this example is then 32 ft, not 35 ft as obtained by the first approximation or 36 ft as empirically interpreted on the original field profile.

Fractured Zones: As indicated in Fig. 1, two areas of fractured zones have been outlined. To determine the presence of such zones the original field profiles were used in the manner shown in Fig. 7. These data illustrate the interpretation of the fractured zone centered at coordinate 2.0-AA. As demonstrated throughout the survey, when the dolomite bedrock was encountered the apparent resistivities increased rapidly. As long as these resistivities continued to increase to the depth measured, it could be assumed that the rock was sound and free from fractures or cavernous conditions. Wherever such conditions do prevail in the dolomite a reversal or decrease in apparent resistivity would be expected, especially during the time of the survey when the water table was high. Of the six curves shown in Fig. 7, three exhibit reversals in resistivity trends and have been noted as the "fractured zone." The fractured zone centered at coordinate 3.5-F affected many more stations than the one illustrated. In this latter case it is quite possible that fracturing extended up to the overburden. This is probably reflected in the slight drainage pattern in the original topography.

Conclusions: From a practical point of view the survey was successful, for it indicated that bedrock would not be encountered in any excavation required for the proposed buildings. The interpretation of results, however, points up the need for both empirical and theoretical analysis even on what appear to be the most obvious in field results, and experience in this particular survey shows the advisability of several methods of interpretation.

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Technical Note

SPHALERITE FLOTATION WITH GUANIDINE COMPOUNDS AND DERIVATIVES AS COLLECTORS

by PIERRE R. HINES

Diphenyl guanidine is used as an accelerator in vulcanizing rubber. Other rubber accelerators are also flotation collectors, e.g., dithiocarbamate, thiazole, and the xanthates.

Urea and its derivatives are good flotation collectors,[1] and guanidine is the nitrogen analog of urea. These two characteristics suggested testing diphenyl guanidine as a flotation collector. Diphenyl guanidine has been tried in flotation work previously, but references give no details.[2-4]

Bunker Hill Co. of Kellogg, Idaho, supplied the ore sample used in these tests. The sample was typical of the ore milled in 1949 and contained 4.52 pct Pb and 1.08 pct Zn. A flotation test made by the author with potassium ethyl xanthate as a collector, the same flotation reagents, and the same grind employed in regular Bunker Hill mill practice was the standard for comparing results with the compounds and derivatives of guanidine.

The compounds and derivatives of guanidine are only fair collectors of galena. However, if potassium ethyl xanthate were used in the galena float, its presence later in the sphalerite float would make it impossible to introduce another type of collector and be certain which collector contributed the result, so the compound or derivative of guanidine under test was used in both the galena and sphalerite floats in Table I. On both the galena and the sphalerite in the Bunker Hill ore, the depressing action of sodium cyanide and zinc sulfate is much greater with collectors of the guanidine type than with the xanthates. If the depressing agents are left out when a guanidine type of collector is used, but a pH of 8.6 is maintained with either lime or sodium carbonate, the depressing action is approximately the same as in the standard xanthate test. Consequently the depressing agents, sodium cyanide and zinc, were not used in the galena floats of tests 1226, 1228, and 1286, Table I, so the galena floats would be on a comparable basis with the standard xanthate test.

As shown by the tests in Table I, the loss in the tail when diphenyl guanidine is used is 8.3 to 9.3 pct, as compared to 17.6 pct with potassium ethyl xanthate, or a recovery of 2.3 to 2.0 lb more zinc. Concentrate grade is 13.7 pct with potassium ethyl xanthate and increases to 22.9 and 31.8 pct with diphenyl guanidine, showing a much higher selectivity. Unless the Barrett's No. 4 coal tar creosote is considered to be a collector, no collector other than diphenyl guanidine is present in the tests, Nos. 1226, 1228, and 1286.

Tests 1218, 1253, and 1263 in Table II were run to check the effect of the depressing agents used in flotation of the galena (sodium cyanide and zinc sulfate) upon subsequent flotation of sphalerite by diphenyl guanidine. Urea was substituted for potassium ethyl xanthate in tests 1253 and 1263 because it is a good collector for galena and a poor one for sphalerite, and the effect of the depressing agents is more marked with urea than with potassium ethyl xanthate. Test 1205 checks the effect of urea alone without any depressing agents when used for the flotation of galena.

Table II shows that diphenyl guanidine as a collector for sphalerite is compatible with other flotation reagents used in floating galena. When the depressing agents sodium cyanide and zinc sulfate are used in the galena flotation step, the amount of lime in the sphalerite flotation must be increased (compare 1253 and 1263).

Table III gives some of the compounds of guanidine which were tested and compared. Some of the compounds and derivatives of guanidine* are soluble in water and others are not. Those tested were fed dry.

* Diphenyl guanidine is in commercial production and is available on the market.

When an organic collector is promising, its compounds and derivatives should be tested and their comparative collecting power recorded. Eventually, in this way, it may be possible to discover some of the essential chemical characteristics of a good collector. For example, it is interesting to compare the diphenyl and dibutyl derivatives in Table IV with those of urea in Table III, Example 3, U. S. Patent 2,664,198. All are good collectors.

Table I shows some of the effects of lime on recovery of sphalerite by diphenyl guanidine. Table V

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TN 462B. Manuscript, Sept. 29, 1958.

Table I. Compounds and Derivatives of Guanidine in Floats

	Tail Assay and Zinc, Pct	Total Zinc Lost in Tail, Pct	Concentrate Grade, Zn, Pct	Collector
Standard Z-3	0.22	17.6	13.7	Z-3
1226	0.11	8.3	24.0	DPG
1228	0.09	8.5	22.9	DPG
1286	0.12	9.3	31.8	DPG

Reagents, Lb per Ton, Standard Test

Galena Float	Sphalerite Float
0.06 Z-3, 1.1 Na_2CO_3	0.33 $CuSO_4$, 0.1 CaO, 0.066 Z-3
0.15 NaCN, 0.40 $ZnSO_4$	Pine oil as needed
Bunker Hill frother as required	

Reagents, Lb per Ton, Tests 1226, 1228, and 1286 with Diphenyl Guanidine

1226 0.1 DPG, 1.0 CaO	0.33 $CuSO_4$, 0.1 DPG
1228 0.1 DPG, 1.0 CaO	0.33 $CuSO_4$, 0.1 DPG, 2.0 CaO
1286 0.1 DPG, 2.0 Na_2CO_3	0.33 $CuSO_4$, 0.1 DPG, 3.0 CaO
Bunker Hill frother as required	Pine oil as needed

Bunker Hill Frother	Pct
Amyl alcohol	5
Pine oil	10
Barrett's No. 4 coal tar creosote	85

Table II. Amounts of Galena and Sphalerite Float Reagents

Galena Float Reagents, Lb per Ton

1218	0.06 Z-3	1.1 Na_2CO_3	0.15 NaCN	0.4 $ZnSO_4$
1253	0.1 Urea	4.0 Na_2CO_3	0.15 NaCN	0.4 $ZnSO_4$
1263	0.1 Urea	4.0 Na_2CO_3	0.15 NaCN	0.4 $ZnSO_4$
1205	0.3 Urea	2.0 Na_2CO_3	— —	— —

Sphalerite Float Reagents, Lb per Ton				Tail Assay, Zn, Pct	Total Zinc Lost in Tail, Pct	Concentrate Grade, Zn, Pct
1218	0.1 DPG	0.33 $CuSO_4$	1.5 CaO	0.12	10.9	18.4
1253	0.1 DPG	0.33 $CuSO_4$	1.0 CaO	0.22	18.2	30.8
1263	0.1 DPG	0.33 $CuSO_4$	3.0 CaO	0.13	11.9	24.6
1205	0.1 DPG	0.33 $CuSO_4$	1.5 CaO	0.09	7.8	17.9

shows it even more clearly, for both diphenyl guanidine and guanidine nitrate.

Zinc loss in the tail goes down slightly as pH is raised with lime, but concentrate grade rises rapidly, contrary to the action of most collectors.

The concentrates produced from the Bunker Hill ore by the guanidine-type collectors all have a salt-and-pepper appearance, unlike the uniform ochre color of concentrates produced by xanthates. This pepper-and-salt appearance is due to a greater proportion of a black resinous sphalerite, not to the cleaner grade of concentrate. Edwards[5] gives the percentages of iron in sphalerite with the corresponding shades of color, from 1 pct Fe (colorless to pale brown) up to 10 pct Fe or more (practically black). The Bunker Hill ore is reported to have zinc as "marmatite plus some sphalerite."[6] It is reasonable to assume that the increased recovery by the guanidine type of collectors is due to better recovery of marmatite or *black jack*.

Marmatite is frequently blamed for poor metallurgical results in flotation of zinc ores.[7] Very little is known about the flotation of marmatite apart from sphalerite.[8,9] An example from practice was a rich zinc ore in which the sphalerite occurred in all shades from pale yellow to brown and black. The light-colored sphalerite floated rapidly with very little xanthate, the dark shades only when the amount of xanthate was greatly increased. It would be valuable to know more about the flotation of marmatite, separate from that of sphalerite. There is no proof that marmatite is accountable for the high zinc losses in some mill tails, and no information as to the nature of these losses. The most frequent excuse for such poor results is that a high grade concentrate is more profitable than a high recovery.

Table III. Test Results for Guanidine Compounds

Compound	Tail Assay, Zn, Pct	Total Zinc Lost in Tail, Pct	Grade of Concentrate, Zn, Pct
Guanidine nitrate	0.15	13.5	26.3
Guanidine hydrochloride	0.17	17.1	23.4
Guanidine acetate	0.18	17.6	21.1
Amino-guanidine bicarbonate	0.30	32.4	13.2
Cyano guanidine	0.41	38.1	15.0
Guanidine carbonate	0.46	40.4	15.7
Guanidine sulfate	0.49	40.8	14.5

Table IV. Some Derivatives of Guanidine Tested and Compared

Derivative	Tail Assay, Zn, Pct	Total Zinc Lost in Tail, Pct	Grade of Concentrate, Zn, Pct
1-3 Di-o-tolyl-guanidine	0.12	9.8	24.1
Dibutyl guanidine picrate	0.12	10.9	12.1
N N' di-n-butyl guanidine nitrate	0.12	12.2	11.7
Diphenyl guanidine	0.12	9.3	31.8
Methyl guanidine sulfate	0.13	13.8	11.7
Triphenyl guanidine	0.19	16.4	21.6
Dimethyl guanyl guanidine	0.27	25.3	22.6
Potassium ethyl xanthate	0.22	17.6	13.3

Table V. Effects of Lime on Recovery of Sphalerite by Diphenyl Guanidine

Lime, Lb per Ton	pH	Assay Zinc in Tail, Pct	Loss Total Zinc in Tail, Pct	Concentrate Grade Assay, Zn, Pct
		Diphenyl Guanidine		
1.0	8.6	0.13	11.4	20.3
2.0	9.2	0.13	11.5	28.6
3.0	9.8	0.13	11.2	30.2
		Guanidine Nitrate		
1.0	8.6	0.16	14.7	21.4
2.0	9.2	0.16	14.6	25.6
3.0	9.8	0.15	13.5	27.6

CONCLUSION

Diphenyl guanidine gives a better recovery of the sphalerite and marmatite in the Bunker Hill ore, and with a higher grade concentrate than potassium ethyl xanthate. Further test work on other zinc ores is needed to determine fully what the characteristics of the guanidine-type collectors are and whether or not these collectors can be generally applied.

The diphenyl and dibutyl derivatives of both urea and guanidine are excellent flotation collectors. The relationship of diphenyl and dibutyl structures to their collecting properties has not been determined.

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9 I. W. Wark: *AIME Trans.*, 1934, vol. 112, pp. 245, 253, 265.

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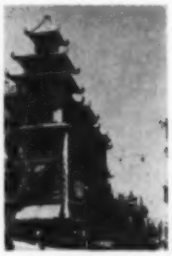
Reports of Your Technical Society

FEBRUARY IS SAN FRANCISCO MONTH



for SME's part in the AIME Annual Meeting. For last minute stories on Welcoming Luncheon and All-Institute speakers, turn to page 222. On this page, MINING ENGINEERING also salutes the hardworking committee from the San Francisco Section who have been responsible for the many plans and preparations. Late abstracts for SME technical papers are printed in the "Mineral Information" section beginning on page 115. Remember, the Sheraton-Palace is SME Headquarters, February 15 to 19.

ATTENTION - - -

SME MEMBERS

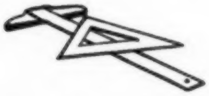
Turn over the opposite page for start of SME's Membership Application. Help a professional colleague fill it out this month . . .

Continuing coverage of technical meetings—reports on the Arizona Section annual meeting in December 1958, page 226, and the Pittsburgh Section annual Off-the-Record meeting in November, page 230. Summary of plans for the forthcoming University of Arizona FluoSolids Reactor Symposium are given on page 236.

Annual salute to the incoming AIME President—Howard C. Pyle in 1959—is presented on page 151.

NEWSLETTERS . . .

- Coal News page 233
- IndMD page 225



EDUCATION NEWS—223

SCHOLARSHIPS—236

DECEMBER COVERS

A limited number of these gold and black covers, without logo and suitable for framing, are still available. Price: 50¢, members; $1.00, non-members. Payment must accompany orders.

Progress Report on United Engineering Center—Page 237

MINING ENGINEERING wishes to salute SME's Western Preprint chairman—Richard M. Stewart, California Division of Mines. Located in San Francisco, Mr. Stewart has been working for almost a year in close cooperation with Society Headquarters to arrange for printing facilities, meeting space, and convention aids for the Society Preprint Program at the Annual Meeting.

Roger Revelle To Give All-Institute Address

Minerals Under the Oceans is the subject of the All-Institute Session address given by Roger Revelle on February 17 at the Annual Meeting. Dr. Revelle is director of Scripps Institution of Oceanography at the University of California. The session will be in the Rose Room of the Sheraton-Palace Hotel in San Francisco.

Dr. Revelle received a Ph.D. from the University of California in 1936. He began his career at Scripps Inst. in 1931 as research assistant and became assistant professor, associate director, and finally director in 1951. He is a member of the International Council of Science Unions. He has been a naval officer in Radio and Sound laboratories and was with the Joint Task Force No. 1 in 1946. Also he has contributed many papers and articles to scientific publications.

Distinguished Nuclear Expert Addresses Meet

An important event of the Annual Meeting is the welcoming luncheon on Monday, February 16, in the Garden Court and Rose Room of the Sheraton-Palace Hotel, San Francisco. The luncheon will be honored by the noted scientist Glen Theodore Seaborg who will give the major address.

Dr. Seaborg is chancellor of the University of California and has held many positions of authority in the nuclear chemical field. He was secretary chief of metallurgical laboratory at the University of Chicago from 1942 to 1946. During these years he did research in nuclear chemistry, physics, and artificial radioactivity. He was co-discoverer of many new elements including: element 94 (plutonium); nuclear energy source isotope Pu-239; uranium U233; element 95 (americum); element 96 (curium); element 97 (berkelium); element 98 (californium); element atomic number 99 (einsteinium); element 100 (fermium) and element 101 (medelevium).

Dr. Seaborg has been a member of the general advisory committee of the Atomic Energy Commission. His many awards and honors include an Award in Pure Chemistry from the American Chemical Soc. and the Nobel Prize in Chemistry for 1951.

San Francisco Section Will Host Feb. Meeting

Our host for the Annual Meeting, the San Francisco Section, announced the 1959 officers at their monthly dinner meeting at the Engineers Club January 14. These men will welcome registrants from all over the country on the opening day, Feb. 15. Pictured here is *Laurance T. T. Kett* who was installed as chairman of the section. He is general manager of Mountain Copper Co.

Douglas J. Kramm, the new vice president, will also be on hand to make the conventioneers feel at home. Mr. Kramm is district manager of Traylor Engineering and Manufacturing Co. The new secretary-treasurer is *William I. Watson* of Arthur D. Little Inc.

Newly-elected members of the Section's executive committee are: *James P. Bradley* of Bradley Mining Co.; mining consultant *Rodgers Peale; E. M. Barker* of Calaveras Cement Co.; and *L. A. Norman, Jr.*, of Equipment Engineers, Inc.

A vote of thanks goes to these new officers and their committees for premeeting plans. Be sure to search them out at the convention for information or just a warm western welcome.

Plans For February Annual Meeting Were Discussed by San Francisco Section Men

Some of the San Francisco Section committee members who were busy making plans for the Annual Meeting gathered at the Pacific Union Club on Wednesday, Nov. 19, 1958. Shown left to right are (seated) O. E. Duling, secretary-treasurer; L. A. Norman, Jr., vice chairman, general committee; E. M. Barker, chairman, general committee; Newell Appleton, AIME convention manager; and Walter Penick, chairman, banquet committee. Standing are B. B. Woodward, Jr., chairman, cocktail party; George Playter, chairman, finance committee; James Bradley, representing the San Francisco Section's executive committee; Jack How, chairman, welcoming luncheon; Rodgers Peale, chairman, reception committee; William Watson, chairman, technical session arrangements; Douglas Kramm, chairman, entertainment committee; and G. W. Mein, chairman of the publicity committee. Missing in this photo are John Bradley, chairman, stag banquet committee; Weston Bourret, chairman, souvenirs committee; W. W. Mein, Jr., chairman of the advisory committee; and Richard W. Stewart, SME Western preprint committee, who also were active.

Education News

Columbia University

A possible answer to America's shortage of scientific manpower might be programs such as the science honors program at Columbia University's School of Engineering, involving '58 high school students.

They have been selected from public and private schools in New York and surrounding areas. Tests of science comprehension and mathematics were given to 219 candidates nominated by the high schools in order to select the participants. Since 25 pct of the high school students scored as high as the top 10 pct of college freshmen classes, the program was enlarged to provide training for these exceptional youngsters. A $25,000 grant was obtained from the Ford Foundation for such expansion.

The experiment is divided into two sections: 1) a lecture-demonstration-laboratory visit program dealing with the most recent developments in several scientific areas, and 2) advance science education through experimental projects in the laboratories.

There also will be informal luncheons where leading scientists will join the students to discuss their scientific interests and goals. An advisory program will give career guidance to the future scientists.

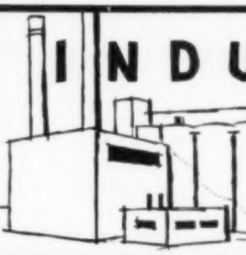
The program was the outgrowth of conferences held at Arden House in Harriman, N.Y., under a grant from the Hebrew Technical Inst. of New York. Purpose of the program is to enrich the scientific knowledge of the students at an early level, in the elementary or high schools where future college courses are decided.

Ontario Dept. of Mines

Classes for prospectors sponsored by the Ontario Dept. of Mines are again in progress this winter in about 12 centers throughout the province. These classes were inaugurated in 1894 and have become a traditional service of the department. The first two towns selected this year were Ansonville and Hearst. It is expected that a cross section of laymen will receive an insight into geology and a comprehensive grounding in prospecting techniques, requirements of the Ontario Mining Act, and other subjects.

University of Arizona

See page 236 for news of an educational program and symposium covering the application of the FluoSolids reactor to the mineral industry.



INDUSTRIAL MINERALS NEWSLETTER

New Division Officers Announced

By the time this appears in print, many of us will be at San Francisco enjoying the fruits of hard work and extra hours put in by Bob Grogan, division chairman, Ray Feierabend, program chairman; and all of the commodity chairmen for 1958-59.

A timely and fascinating talk is in prospect for the Industrial Minerals luncheon at San Francisco. The speaker will be George F. Taylor, manager, Flight Information Evaluation Section of Lockheed Aircraft Corp. Dr. Taylor has an extremely broad background, inasmuch as he carried on graduate work in geology and worked as a geologist both for the Union Oil Co. and the U. S. Geological Survey; later, he became chief meteorologist of American Airlines and has worked in the field of meteorology for other airlines and while in service. He also served as a special advisor to the Atomic Energy Commission.

The organization for 1959-60 is now well in hand and, in addition to the nominated and elected officers listed in the July 1958 issue of MINING ENGINEERING, the following appointments have been made by the chairman-elect: Nominating committee, *Robert M. Grogan*, E. I. duPont de Nemours & Co. Inc., chairman; *Leon W. Dupuy*, U. S. Bureau of Mines, program chairman; *John S. Holland*, National Lead Co., SME chairman; *F. C. Kruger*, International Minerals & Chemical Corp., chemical raw materials chairman; *Howard L. Hartman*, Pennsylvania State University, dimension stone and slate head; *Ralph H. Wilpolt*, The Superior Oil Co., rare and radioactive minerals chairman; *William F. Guyton*, William F. Guyton & Associates, industrial waters chairman; *R. S. McClellan*, Gouverneur Talc Co. Inc., fillers, fibers & pigments chairman; *Wayne E. Brownell*, New York State College of Ceramics, ceramic raw materials chairman; *Herbert E. Dux*, Pennsylvania Glass Sand Corp., special sands and abrasives chairman; *James V. Thompson*, Kaiser Engineering Inc., mineral aggregates chairman; and *Ross W. Smith*, Colorado School of Mines Research Foundation Inc., cement, lime and gypsum chairman.

Fall Meeting

Planning has already started for the joint IndMD-Coal Div. fall meeting to be held at Bedford Springs, Pa. on Sept. 24 to 26, 1959. John J. Schanz, assistant professor of mineral economics at the Pennsylvania State University, will serve as general chairman of this meeting. Preliminary plans include four Industrial Minerals sessions, one coal session, and one joint session to be arranged by Leon Dupuy, as program chairman, together with officers of the Coal Div. There will be two official luncheons and one dinner at the latter of which we hope to have neither a speech nor a program. Bedford Springs in late September is advertised as a delightful spot so that, in addition to the papers, we know that the anticipated group of probably 400 will enjoy the recreational facilities and may even sum up enough ambition to take part in a field trip on the final day.

This is your editor's last assignment as secretary-treasurer of the division, and I hope that you will extend to Ray Feierabend, my successor, the same pleasant cooperation that I enjoyed.

Editor

Address news items to: John G. Broughton, IndMD Secretary-Treasurer, State Education Building, Room 448, Albany 1, New York

ARIZONA SECTION ANNUAL MEETING CELEBRATED IN TUCSON

The annual meeting of the Arizona Section was held in Tucson on Dec. 1, 1958. Registration began at 8 am in the mezzanine of the Pioneer Hotel. Approximately 500 attended the statewide meeting to participate in technical sessions, directors' meeting, dinner, and entertainment.

Board of Directors

At 2 pm in the Bamboo Room the board of directors held their annual meeting, beginning with the minutes of the last meeting, Dec. 2, 1957. The financial report was discussed and a suggestion made to charge a registration fee that would sufficiently support the annual meeting. A. P. Morris, re-elected chairman of the Section, appointed a committee to study the need for registration fees. Guest of honor, Howard C. Pyle, President-Elect of AIME, stated that he felt that all AIME meetings should be self-supporting.

J. D. Forrester then reported on the 1958 Student Paper Awards. Of the nine entries the following were the winners: First Prize $50—John H. Meyers, *A Method For Determining Relative Effects of Truck Capacity, Haulage Distance and Grade Upon Haulage Costs in Open Pit Mining;* Second Prize $35—G. M. Chaplin, *Germanium;* Third Prize $15— E. D. Albrecht, *Nickel—From Saxony to Sudbury.* The winning papers were sent to New York for submission in the national contest. The Student Paper Contest will be continued next year.

A committee was established to study the educational kits prepared by the Engineer's Joint Council. Requirements for high school graduation were discussed in regard to qualifications for engineering courses in college. J. A. Wilcox stated that many students are not properly equipped and that boards of education should be more concerned with improving their curricula. J. D. Forrester reported that the Board of Regents is working on strengthening requirements for University of Arizona entrance and that new requirements would eventually be reflected in high school courses. It was pointed out that it will be necessary to overcome the resistance of a great many parents before requirements in science and mathematics can be strenghtened.

C. R. Kuzell reported that 52.29 pct of the quota for the United Engineering Center Campaign has been pledged. So far the Section has promised $3660 for the new building.

President-Elect Howard C. Pyle addressed the directors and the meeting was adjourned.

Other top officers, in addition to A. P. Morris, who were re-elected include: W. C. Lawson, first vice president; T. A. Snedden, second vice president; and C. L. Hoyt, secretary-treasurer. Other guests of honor were J. C. Fox, SME Secretary, Rixford Beals, *Mining Engineering* editor, and R. A. Harvill, president of the University of Arizona.

Technical Sessions

Technical sessions on mining geology, underground mining, smelting, open pit mining, and mineral dressing filled the day. The mining geology session, under chairman J. B. Wertz, included the following papers: *Plant and Soil Prospecting for Nickel:* C. P. Miller; *The Geological Map of Arizona:* E. D. Wilson and R. T. Moore; and *Dating Metalliferous Ore Deposits*: P. E. Damon.

Underground mining, under chairman A. J. Fenn, included: *Underground Concreting at San Manuel Mine:* M. H. Ward; and *A Resume of Recent Blasting Methods:* A. W. Ruff.

The session on smelting had one paper by G. E. Morris on *Smelting at Chuquicamata, Chile*, under the chairmanship of Henry Allen.

Open pit mining, under chairman R. E. Thurmond, included *Dust and Its Control in Open Pit Mines* by J. P. Harmond; *Foremen's Training, Copper Queen Branch,* by G. E. Travis; and *Benefits of Truck Haul-*

For the first time in several years the board of directors gathered before the meeting for a group shot. Among them is their noted guest Howard C. Pyle. Other guests not in evidence are J. C. Fox and Rix Beals. In alphabetical order, but not as shown, the directors are: L. M. Barker, A. T. Barr, A. B. Bowman, J. F. Buchanan, T. G. Chapman, B. R. Coil, G. F. Duff, J. D. Forrester, D. Gardner, W. P. Goss, P. D. I. Honeyman, R. W. Hughes, M. W. Keevan, C. R. Kuzell, W. C. Lawson, A. Mendelson, C. E. Mills, H. F. Mills, A. P. Morris, J. B. Pullen, J. A. Richards, G. H. Ruggles, T. H. Snedden, E. D. Spaulding, H. C. Weed, R. F. Welch, J. A. Wilcox, C. F. Willis. Two hours of talk followed.

age Improvements by J. C. Van De Water.

The final session under chairman T. R. Herndon was on mineral dressing and included papers by H. W. Franz on *The L-P-F at Hayden, Arizona;* C. B. Kettering on *Dual Process;* and G. A. Komadina on *Pima's Concentrator.*

Social Events

In the evening cocktails and dinner preceded the business meeting. Principal speaker at the banquet was Howard C. Pyle, president of the Monterey Oil Co., Los Angeles. His address was entitled *America's New Frontier.* Other speakers were Richard A. Harvill and C. R. Kuzell, former vice president of Phelps Dodge Corp. and now a director of AIME.

Students at the University of Arizona Colleges of Mines were invited to the banquet to witness the awards for Student Prize Papers. After the reports and elections the banquet ended and dancing began, rounding out the day-long meeting.

In addition to the conference sessions, Mr. Pyle and A. P. Morris visited the University of Arizona College of Mines, along with various Arizona mine managers, where Mr. Pyle addressed the student chapter of AIME and conferred with President Harvill.

The men responsible for the successful conference were the chairman, A. P. Morris, who handled general arrangements; S. L. Smith, in charge of registration; H. E. Krumlauf, technical session manager; and J. D. Forrester, who planned the dinner and entertainment. The gratitude of all who attended goes to these men and their committees for the time and effort they gave.

Section chairman A. P. Morris, right, congratulates W. E. Heinrichs, Jr., for his fine work in the formation of the new Tucson, Arizona, Local Subsection.

The banquet head table sported such notables as AIME President-Elect Howard C. Pyle, chairman Morris, and special guest speaker Charles R. Kuzell.

The popular mining geology session in the ballroom early Monday morning boasted packed attendance and an active discussion. J. B. Wertz was the chairman. At the right Mr. Morris presents the student prize, $50, to John H. Meyers.

PROPOSAL FOR AIME MEMBERSHIP

I consider the following person to be qualified for membership and request that a membership kit be mailed to him:

Name of Prospective Member: ....

Address ....

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....

Name of AIME Member: ....

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SME

CHANGE OF ADDRESS AND PERSONALS FORM

CHANGING YOUR ADDRESS? Don't forget to notify us six (6) weeks before you move, if possible, to insure uninterrupted receipt of your publications and correspondence. Please fill in the form below and send it to: J. F. Lynch, Asst. Treasurer AIME, 29 West 39th Street, New York 18, N. Y.

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Old Address ....

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PERSONALS: Please list below your former company and title and your new title and company (or new work) for use in MINING ENGINEERING. (Copy deadline for personals items is six weeks before date of issue.)

Former Company ....

Former Title .... **Length of Time There** ....

New Company ....

New Title .... **Date of Change** ....

....

Any recent activity that would be of interest to members:

....

....

....

Celebrating the Fellowship Dinner were the head table guests of honor, Section officers, and other notables. From left to right are: R. S. Crowell, Pittsburgh Section secretary; J. H. Melvin, treasurer; D. Laughery; J. M. Vonfeld, chairman; F. M. Richmond; H. R. Loxterman; Vernon Jones; W. L. Kerlie; A. Thornton; Augustus B. Kinzel; J. H. Richards; Leo Rhineharts; E. B. Snyder, National Open Hearth Committee secretary; Max Lightner; J. W. Kersting, winner of the Leo Rhineharts Award; G. B. Warren; J. C. Fox; R. M. Barnhart; Douglas C. Johnston; and H. A. Franke. The dinner was held in the ballroom of the Penn-Sheraton Hotel with cocktails and conviviality before.

The distinguished visitors seen below left added an international flavor to the festivities, and the mass of conventioneers below enjoyed a breather after the technical sessions, courtesy of the many Pittsburgh industries. H. R. Loxterman was chairman of the Suppliers Committee that gave the party.

Photographed at the left is R. M. Barnhart, chairman of the National Open Hearth Committee, Pittsburgh Section who presented the F. L. Toy Award.

The pleasant picture in the corner shows left to right Mrs. Q. E. Wood and Mrs. Gale M. Weisner, both of Quaker State Oil; Mrs. James M. Bird, whose husband is president of Birdwell, Inc.; and Mrs. R. L. Sloboel, Pennsylvania State University. At right this jovial group includes Hershel Beasley of International Nickel Co.; David Booth, University of Pittsburgh; Joseph Martin of Carnegie Inst. of Technology; H. M. McCullough who addressed the Inst. of Metals Group, and G. Soler of Universal-Cyclops Steel Corp.; and James Macbeth, Jr., of Nevill Ferro Alloy left to right.

PITTSBURGH HOLDS 13th OFF-THE-RECORD MEETING

The 13th Annual Off-The-Record meeting of the Pittsburgh Section was held at the Penn-Sheraton Hotel on Nov. 7, 1958. It was sponsored jointly by the AIME Pittsburgh Section, the National Open Hearth Committee Pittsburgh Section, and the Mineral Industries Section of the Engineers' Soc. of Western Pennsylvania.

Over 900 engineers and students attended the successful conference and heard 40 technical papers in the fields of mining, oil and gas production, ferrous and non-ferrous metals, open hearth steel production, ceramics, ore preparation, and exotic fuels.

Credit is due to the committee chairman under F. M. Richmond, the general program chairman. W. B. Jamison of the Coal Division headed arrangements for his group. F. L. Convers was responsible for the Petroleum Subsection plans. G. T. Horne handled the session for the Inst. of Metals Group. J. H. Melvin was in charge of the Mineral Industry Group. And J. N. Albaugh made arrangements for the National Open Hearth Committee program. The speakers and subjects proved that careful planning can make a successful conference.

Students were invited to attend the Fellowship Dinner and 111 enjoyed the evening's entertainment. The featured speakers are pictured at the right and the head table is seen below.

The Coal Division morning session met in the Monongahela Room of the hotel with co-chairmen W. E. Hess and E. B. Nelson. The papers presented are as follows: *Guidance Systems for Continuous Miners* by E. D. Purdum. *An Engineering Approach to Underground Ventilation and Dust Control* by Lee Barrett. *Mine Costs and Production Controls Developed from an Industrial Engineering Program* by Myron Kok. In the afternoon the chairmen were D. H. Davis and P. L. Richards.

The Petroleum Subsection morning session was under the chairmanship of Frank J. Lydick and G. M. Mitchell. A film on *Gas for Appalachian Markets* followed a short business meeting. G. R. Bond and William Wertman presented papers to complete the session. In the afternoon the chairmen were H. J. En-Dean and Paul Cunningham.

Co-chairmen for the Inst. of Metals Group session were R. Lula and G. M. Pound. The morning session met in the Allegheny Room and included four papers. The afternoon chairmen were E. J. Dulis and J. J. Heger.

The National Open Hearth Committee had their morning session in the Urban Room. Operating chairman was W. T. Sergy. Metallurgy co-chairmen were B. M. Shields and E. R. Morgan. A three-fold discussion of the performance and properties of desirable charge oxides was presented by D. R. Bailey, A. G. Dean, and A. J. Parke. Then J. H. Chesters gave a paper entitled *Factors Controlling Iron Oxide Deposition in Open Hearth Furnaces.*

In the afternoon session W. P. Yerrick and David Cousley were co-chairmen. Another three-fold presentation was given by A. I. Gorman, J. A. Cerroni, and C. F. Smith on *Effect of High Firing Rates.*

The Mineral Industries Group had A. S. Russell and E. S. Wheeler as co-chairmen in the morning, Frank C. Sturges and W. M. McKewan in the afternoon. A film began both sessions and the interesting papers included: *Rare Earth Alloy Steels*: by W. E. Knapp; *High Energy Fuels* by George Huff; *Specific Cermets and Ceramics of Promise* by M. F. Judkins, and many more.

Climax of the day-long conference was the banquet in the ballroom with 400 attending. J. M. Vonfeld, chairman of the Pittsburgh Section, pictured at top, served as toastmaster. Mr. Barnhart presented the F. L. Toy Award to W. L. Kerlie and J. H. Richards for their paper "The Origin and Elimination of Hydrogen in Basic Open Hearth Steels". Max Lightner, vice president of U. S. Steel Corp. and next in the column, introduced Glenn B. Warren (right), vice president of General Electric Co. who spoke on the engineer's responsibility to foster social and moral advancement as well as technical progress.

Mining & Metallurgy Congress Will Convene in Germany, May 21, 1959

The School of Mines of Freiberg, Saxony, is sponsoring the 11th Mining and Metallurgical Congress in memoriam of Alexander von Humboldt on the 100th anniversary of his death. The conference begins Wed. May 20 with the naming of the new Inst. for Geology, Leipzigstrasse, and the opening of an Alexander-von-Humboldt memorial exhibit in the city and Mining Museum.

Alexander von Humboldt was a versatile German naturalist whose geological studies covered unknown areas of the New World, the waters of the Orinoco and Amazon, and produced the volumes called the *Kosmos* comprising the scientific knowledge of his time. An address on the *Outstanding Scientist of the People* will be given by A. Watznauer.

Official opening of the Congress will be on Thurs., May 21, with welcoming remarks by the Dean of the School of Mines, H. Haertig.

The technical program will cover many topics including the following: *Ore Deposition*—colloqium on geosyncline deposit; *Geology*—addresses on the old paleozoic of Saxony and Thubingen and the glazigenic structure and stratigraphy of the Pleistocenes; *Geophysics*—colloqium on engineering geophysics and geophysics in mining; *Underground Mining*—shaft excavating in Saxony; mechanization of shaft excavating; shaft excavating in Central Germany and in Thuebingen in a quasi-plastic mountain range; reconstruction of a combine for speed excavating as well as for speed driving of tunnels with circular profile; problems of rock tunnel driving; and organization of fast tunnel driving.

Open Pit Mining will discuss actual techniques and economic questions. *Mine Safety* will cover dust prevention. *Mechanical Engineering and Electro technique in Mining* will cover the following five aspects: analysis of the motion ratio and the resulting dynamic stress on belt conveyors; problems of transloading of bulk materials of different kinds; measuring methods for the determination of conditions of visibility in dusty mines; theoretical analysis and experience with the 30 k-V feeder with open pit heavy equipment; and results of the tests of pneumatic hammers of the Research Inst. for drilling and shooting technique.

Other sessions will include: *Engineering economy*—with lectures on the usefulness of investing in mining; *Mine surveying; Mining law; Briquetting—Technical fuel utilization; Gas production;* and several sessions on *Metallurgy*, including the new research methods to explain fundamental metallurgical operations, new developments in processing low grade raw material, and fundamentals of dry and electrochemical metal cleaning methods.

Special events and exhibits will complete the program, with sightseeing, visits to the State Opera in Dresden and to churches and museums. There will be concerts given by the Dresden Philharmonic Orchestra. The ladies will have their own special highlights and get-togethers throughout the Congress.

Participants are requested to send in their names by March 1, 1959. Please write for information to: Aussenininstitut der Bergakademie Freiberg/Sa., Akademiestrasse 6.

EJC Officers For 1959

The Engineers Joint Council has announced the re-election of Enoch R. Needles as president at the board of directors meeting, January 16. The new vice president, Augustus B. Kinzel, also assumed office on that day.

Mr. Needles has been identified with the financing, design, and construction of major expressways and bridges. A graduate of the Missouri School of Mines, he has been long active in engineering society affairs.

Dr. Kinzel, Past-President of AIME, is vice president for research at Union Carbide Corp. He has been a pioneer in ferro-alloys, atomic energy, and a new process for making titanium metal. A graduate of Columbia University, Massachusetts Inst. of Technology, and the University of Nancy, France, where he was awarded a Ph.D., he has been with Union Carbide since 1926.

In the January issue a summary of Coal Division activities during the past year included reports by committee chairmen. See that issue, page 85, for a full account. The committees that have sent in their reports since the time of publication are reviewed this month.

Mining Committee

Chairman of the mining committee, Ernest M. Spokes, described the purpose and activities of his committee as follows:

"The mining committee consists of a chairman and four subcommittees: anthracite mining methods, bituminous mining methods, maintenance, and safety and ventilation. Its function is to seek out authors to write and present papers at the various Institute meetings, and to encourage them to submit their papers for publication in MINING ENGINEERING.

"The committee chairman receives requests for papers from the program committees of the various meetings, and transmits these requests, with suggestions, to the committee members, with instructions on method of submission and deadlines. Frequently, the committee members suggest papers and authors to the chairman, who then proposes these papers to program chairmen of forthcoming meetings.

"Occassionally a subcommittee will make a detailed study of practices within its province, such as the organization for maintenance and the variation in maintenance costs at mines of different size or type of operation. It is hoped that such studies will result in worthwhile publications.

"The committee welcomes offers to prepare papers, or suggestions of subjects or authors; they may be addressed to any member of the committee individually, or to the chairman of the committee or of any subcommittee."

Preparation Committee

Mr. Spokes thorough coverage of committee activities gives a clear picture of the work accomplished by many different groups. Another report, from the preparation committee, similarly describes subcommittee action. D. A. Dahlstrom, chairman, has three chairmen of subcomittees to help him: Paul L. Richards, coal processing subcommittee; Frank R. Zachar, development and plant design subcommittee; and Victor Phillips, solid-fluid separation subcommittee.

These three subcommittee chairmen and Mr. Dahlstrom met with William Hess, program committee chairman, to decide on symposia topics for the Annual Meeting. One session was developed by Vic Phillips entitled *Water Cricuit Problems In Coal Preparation Plants.* Mr. Dahlstrom and Mr. Richards are co-chairmen of that session.

The other session is headed by F. R. Zachar and H. F. Yancey, entitled *Cleaning Plant Design for Economical Operation.* They have compiled three papers for the program.

Combustion Committee

Combustion committee activities are directed by T. S. Spicer. His report states that the function of the committee is to assist in securing papers and session chairmen for the Joint Solid Fuels Conference and the Annual Meeting. The committee members have been active in this work during the year.

Charles C. Russell reports that his subcommittee on carbonization and gasification obtained the following papers for the Annual Meeting: *Transportation of Coal by Pipelines*, by V. D. Hanson, Consolidation Coal Co.; *Coke Combustibility, A Negative Characteristic*, by John D. Price of Colorado Fuel and Iron Co.; and *Determination of Coke Oven Productivity from Coal Charge Characteristics*, by A. H. Brisse, U. S. Steel Corp.

By the time of publication, Coal Division members will be witnessing the results of these committee endeavors.

Around the Sections

• A film on *Milling and Smelting the Sudbury Nickel Ores* was the main feature of the **Tri-State Section** meeting, November 19, at Baxter Springs, Kan. A social hour preceded the regular meeting.

• The **St. Louis Section** held elections on November 14 at the Hotel York. Gill Montgomery became chairman; Gordon M. Bell was elected vice chairman; and Norman S. Geist is the new secretary-treasurer. Speaker for the evening was Edward Orban, manager of inorganic product development, Monsanto Chemical Co. Dr. Orban discussed the present potential in the electronic industry for lesser known elements such as germanium, silicon and beryllium.

At the December 12 meeting Lute J. Parkinson, professor at Colorado School of Mines, recounted his experiences in Africa where he was exploring for diamonds.

• A summary of fall meetings of the **Colorado Section** includes the September meeting where L. W. LeRoy, head of the geology department of the Colorado School of Mines, spoke on *Geological Aspects of the Moon's Surface*.

The October meeting at the University Club in Denver announced appointments for program chairman: Fred Smith; Section delegate: Lee Scott; and nominating and scholarship committee members.

In November the dinner meeting included regular business and reports, with a financial discussion concerning the United Engineering Center. Speaker for the evening was E. H. Crabtree, Jr., who reported on the Atomic Energy Conference in Geneva, Switzerland.

Elections took place in December. The new officers are W. L. Miles, chairman; Arthur L. Hill, vice chairman; Alfred C. Hoyl, secretary-treasurer, plus directors and committee members.

• The **San Francisco Section** met on October 8 for an analysis of boom and bust with suggestions for eliminating depressions, in a talk by Ira B. Jaralman entitled *Whims and Pyramids*.

On November 12 the annual student's meeting featured a discussion of U. S. and European educational systems.

The Christmas Party was complete with floor show and Christmas booty.

• The November **New York Section** meeting presented Ira K. Hearn of Kennecott Copper Corp. for a lecture on *Industrial Engineering Applied to Mining*.

• Reviewing the meetings of the **Mexico Section**, it seems that the July session was overlooked. The Section president, Eduardo Guzman, opened the meeting and presented the guest speaker Carlos Castillo Tejera who discussed the petroleum industry in Mexico.

In November the Section held a dinner for Augustus B. Kinzel and Mrs. Kinzel, and in December Luis de la Pena was the speaker for the meeting at the University Club.

• The September meeting of the **Montana Section** in Columbia Falls featured a talk by L. Holscher, Kaiser Aluminum Co. The meeting was co-sponsored by the Anaconda Aluminum Co. Technical Soc. who led a group on a tour of the plant.

The Montana Section joined the Butte Mineral and Gem Club on October 22 at the Montana School of Mines for a talk on *Volcanology* by Murl H. Gidel.

Their annual Great Falls meeting was held on Novembr 1 at the Schell Town House, with Ed Woster as speaker and the Anaconda Aluminum Co. as host. On Nov. 22 the annual Helena meeting was held jointly with the Last Chance Gulch Mining Assn. Edward Bonner spoke on the Berkeley Pit.

The December meeting included elections. Chairman for 1959 is James J. Dougherty. Vice chairman is G. T. Hanson; Koehler Stout is secretary-treasurer; and executive committee members were chosen. The principal speaker after dinner was Roger Pierce.

• The **Ajo Subsection,** Arizona Section, met November 11 with guest speakers J. D. Forrester and T. G. Chapman. Their Christmas Party was held on December 18.

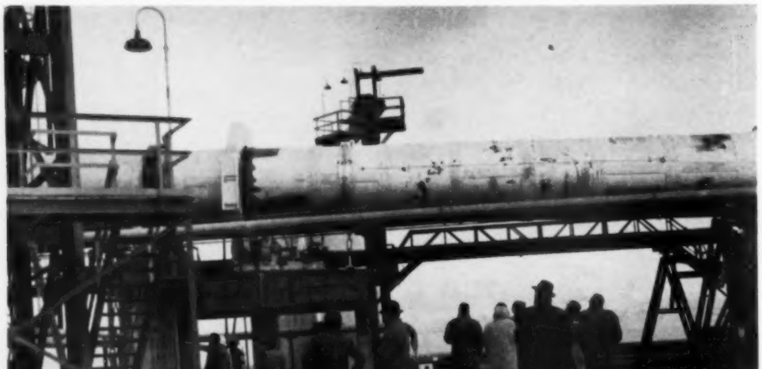
• The **Southern Nevada Subsection** held a field trip on November 9 at the Mountain Pass mine and mill of the Molybdenum Corp. of America, Nipton, Calif. The tour highlighted the rare earth operation.

• Principal speaker at the **Spokane Subsection,** Oregon Section meeting November 26 was R. L. Tobie. His topic was *Iron Mining Underground in Michigan*.

• Meetings of the **Reno Subsection,** Arizona Section, included an October session where Charles J. Armstrong, president of the University of Nevada, was principal speaker.

A tour of Eagle Picher's Colado diatomaceous earth plant, cocktails at the Meadow Hotel in Lovelock, dinner in the Patio Room, and several guest speakers were features of the November meeting.

A luncheon meeting December 12 was held at the U. S. Bureau of Mines with a tour of the facilities. Donald J. Bauer and Edward Morrice, both of USBM, were the speakers.



Touring the new plant of the Eagle-Picher Nevada operations are AIME members led by John Kinner, general manager of the Caloda diatomaceous plant, in the picture at left.

The Annual President's Night, high point of the year for the Ohio Valley Section, was held at Ricardo's in Columbus, November 13. WAAIME joined the festivities with special luncheons for Mrs. Augustus B. Kinzel while Dr. Kinzel toured the Battelle Memorial Inst. Pictured here are Ernest Kirkendall, AIME Secretary; J. R. Lucas, chairman of the Section; Dr. Kinzel, AIME President and Clyde Williams, Past President, to represent the Institute.

• **The Prospector's Club, Student Chapter** at Ohio State University, cooperated in presenting an exhibit for the Freshman Engineering Orientation Program, September 25. The display was again presented on Nov. 15 at the Invitational Conference for Engineers.

• An illustrated talk on Russia, given by Ed Beck, Westinghouse Electric Co., was the major feature of the November 12 meeting of the **El Paso Section**. Their Christmas Dance was held at the Hilton Hotel on December 6, 1958.

• The **Oregon Section** November 21 dinner meeting featured guest speaker John C. Kinnear who discussed AIME policies.

The December 19 meeting presented the problems of financing higher education, with Errett Hummel, assistant to the president of Portland State College, as speaker.

• The **Eastern North Carolina Subsection** had a meeting at the Vance Hotel in Henderson on December 6. Owen Kingman, Tennessee Copper Co., was the major speaker.

• The **Golden Gate Petroleum Subsection,** San Francisco Section, welcomed Paul Witherspoon as guest speaker on November 20 at the Bellevue Hotel.

• President's Night for the **Cleveland Section** had the theme *A Look to the Future* with guests Augustus B. Kinzel, J. M. Cherrie, and P. R. Kyropollos. A panel discussion of the automotive future highlighted this November 20 meeting.

• The **Morenci Subsection,** Arizona Section, presented Ralph Johnson of Western Knapp Engineering who discussed smelter design improvements. This session took place at the Longfellow Inn on Oct. 28, 1958.

• The **Lehigh Valley Section** presented John F. Nielson who gave some of his ideas on why Russia is expanding faster than we are in the race for space. Nielson is professor of metallurgy at New York University and feels that the many Russian visitors, the freely translated American technical publications contribute to Russia's advance. The meeting took place on Oct. 24, 1958.

• The **Ohio Valley Section** announced new officers for 1959: J. R. Lucas, chairman; J. W. Spretnak, vice chairman; and G. H. Schippereit, secretary-treasurer. The annual President's Night was November 13 with special luncheons and dinner for the honored guests. See the photograph at left for details.

• The **Black Hills Section** held a meeting at the Westerner Cafe, Sturgis, S. D., on Dec. 4, 1958. E. H. Stevens was the presiding officer, and the new officers will be announced shortly.

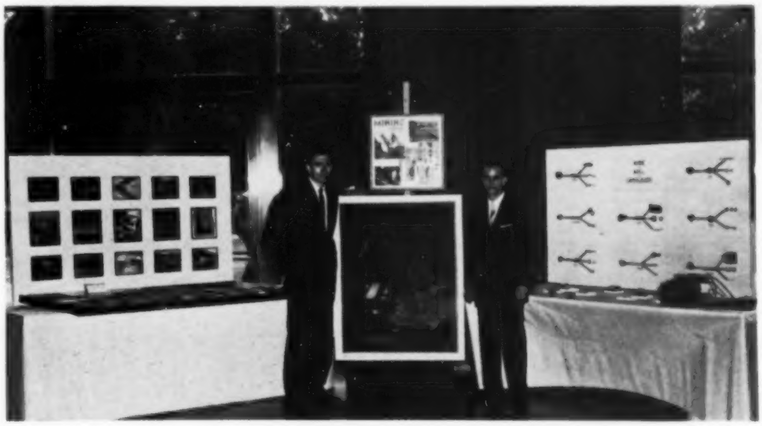
• The November 4 meeting of the **Washington, D. C., Section** opened with cocktails and dinner at the Cosmos Club. Marling J. Ankeny, director of the Bureau of Mines, was the speaker.

• The **Lima, Peru Section** held their December luncheon meeting on the 17th with Alexander H. Kursell, E. J. Longyear Co., discussing *Diamond Core Drilling with Wire Core Barrel.* The program chairman, Edward P. Cadwell, has prepared copies of each speech in Spanish and English to be distributed after the talk.

• The **Southwestern New Mexico Section** held a cocktail-dinner meeting at the Murray Hotel on December 3. S. D. Michaelson, SME President, was the guest speaker.

• The **Uranium Section** met at the M-4 Ranch on November 4 for a social hour, business meeting, the nomination of officers, and a talk by Robert Beverly, National Lead Co.

• A summary of meetings over the past year held by the **Yavapai Subsection**, Arizona Section, includes a variety of topics covered. In April, J. B. Tenny discussed a *New Concept of Bisbee Fault*. In May, J. Q. Jones discussed uranium processing. The film *The Dupont Story* was shown in June and J. A. McAllister told about mining in South Africa at the July meeting. J. B. Wertz spoke on exploration methods in the Belgian Congo at the August session; B. R. Waples, Jr., spoke in September on modern trends in industrial building. The Ladies Night program was held in October and J. D. Forrester spoke in November.



An outstanding mining display was arranged by the Prospector's Club at Ohio State University. Warren Nangle is president of the Student Chapter and J. R. Lucas is the faculty advisor. Pictured with the display are mining engineering students, Howard Rutherford and W. J. Verner.

Scholarships

Guggenheim Fellowships

Daniel and Florence Guggenheim Jet Propulsion and Flight Structures Fellowships will be awarded in April for the year 1959-1960. Application deadline is March 1, 1959. The fellowships are awarded for graduate study at the Jet Propulsion Centers established by the Guggenheim Foundation at the California Inst. of Technology, Princeton University, and the Inst. of Flight Structures at Columbia University.

Each year 18 to 20 awards of $1500 to $2000 plus tuition are provided for advanced professional training. The purpose of these grants is to select and train outstanding men for basic research and leadership in future development of rockets and space flight.

Candidates must be residents of the U. S. or Canada, with outstanding technical ability, preferably with a bachelor's degree in science and under 30 years of age. Applicants who wish to be considered for Jet Propulsion Fellowships should apply directly to either Princeton University of California Inst. of Technology. Applications for Fellowships in Flight Structures should be made to Columbia University.

Ohio State University

Scholarship winners in the Mining Engineering Division of Ohio State University were photographed recently, omitting three others who have received scholarships for the school year 1958-1959.

Beginning at the left the students are Joseph Reitberger, who received his award from North American Coal Corp.; John Patterson, who has been helped by International Nickel Co.; Robert Bouman, Howard Rutherford, Robert Murray, and James Verner, all with scholarships from North American Coal Corp. North American also gave David Sullivan and John Susac scholarships, and Floyd Nelson received an AIME Coal Div. award.

The North American Coal Corp., Cleveland, has established an outstanding student award program at Ohio State where students are given $900 a year and guaranteed summer employment if they wish. This progressive program designed to assist mining engineering education has been successful in attracting well qualified students selected by competitive examination.

University of Arizona To Offer Two Programs On FluoSolids Reactor

An educational program and symposium on *The Application of the FluoSolids Reactor to the Mineral Industry* is being offered by the University of Arizona College of Mines. The program begins Feb. 23, 1959, with five days devoted to the fundamentals of chemistry, physics, mathematics, stoichiometry, and metallurgical thermodynamics as they apply to the FluoSolids reactor.

This first part of the program is designed for engineers who are connected with the operation of the reactor. A four-in FluoSolids reactor, the only one owned by a college of mines for instructional purposes, will be used in the laboratory discussion. The fee for this educational program will be $30.

The second part of the program will be a symposium on March 2 and 3. Technical papers, a panel discussion, and a field trip to the new Hayden smelter, owned by Kennecott Copper Corp., will be the main features. The fee for the symposium includes transportation and a meal during the field trip, for a total of $10.

The program will follow the AIME Annual Meeting in San Francisco. For additional information, contact Sigmund L. Smith, College of Mines, University of Arizona, Tucson, Ariz.

UET Year-End Report on Progress and Problems

This is a summary of progress and problems. By the time it is published and reaches you, in February 1959, there will doubtless be more progress and new, if not fewer, problems. Right now, at the close of 1958, there is a healthy balance of progress and problems; the kind of balance that always stimulates and challenges engineers.

Progress

In a little over a year, the United Engineering Trustees and their Real Estate Committee have secured what the experts call the best site in New York, on the west side of United Nations Plaza between 47th and 48th Streets. The last of the tenants has moved, demolition of the buildings is complete, and the site was cleared early in January. The general contractor should be selected in February.

The architects, Sheve, Lamb, and Harmon Assocs., have completed preliminary plans and called for bids on the general contract. Only a courageous architect would undertake a building for a group of engineers. In this case, courage is reenforced by experience. This firm has for many years been consulting architects to United Engineering Trustees on alterations, and plans for renovation and replacement of the present building on 39th Street.

Many details are yet to be settled, but the basic plan is agreed upon. There will be a twenty-story tower with penthouses rising from a two-story basic structure over a basement. The gross floor area will be 280,000 sq ft. The basement, and two large floors housing the library, cafeteria, and central services will occupy the United Nations Plaza block front. Present plans call for a 13-story wing to provide for expansion when needed about 15 years from now.

Problems

It isn't right to put the matter of finances entirely under the head of problems. More than half the story belongs under progress. Of the 8 millions needed, 5.5 millions have been given in cash or pledged by the end of December 1958. Industry gifts totaling 3.85 millions have been received. Members, 32,000 of them, have given 1.65 millions. Founder Society members (17.7 pct of them) have given 55 pct of the member-gifts quota. More than 40 local sections have met and exceeded their quotas. That's progress.

The only real problem is how to put clearly before every member of the Founder Societies the importance and urgency of this project. *Every local Section that has made a personal appeal to every member has exceeded its quota.* So there is every reason to be sure that the job *can* be done as it should be—on a man-to-man basis where the members live and work.

We are behind schedule and need to put in some overtime to catch up. This will take personal effort on everyone's part. Member campaign solicitors could take a couple of evenings to call on prospects they can't reach in the daytime. Members who haven't been solicited could call their Section chairmen or secretaries to tell them they are ready to make their pledges—ready to lend a hand in cleaning up the campaign in each local Section. The responsibility rests squarely on each member himself.

Geoscience Abstracts Now Published by A.G.I.

Beginning in January, a new periodical entitled *GeoScience Abstracts* replaced the publication *Geological Abstracts* which had been published by the Geological Society of America for A.G.I. The new journal offers a different format, expanded coverage organized by subject matter, and is published monthly. Subscription rates are: $15 to members of AGI Member Societies on GeoTimes mailing list (for personal use only); $35 for nonmembers, for colleges and universities and for public libraries; and $65 to private organizations and government agencies. Payment must accompany the order. *GeoScience Abstracts* is published by the American Geological Inst., 2101 Constitution Ave. N.W., Washington, D. C.

Nuclear Congress Will Convene in Cleveland

The nation's largest gathering of specialists in the atomic field, the 1959 Nuclear Congress, will be held in Cleveland, April 5 to 10. The Public Auditorium will house representatives of the Hot Laboratories and Equipment Conference, the Nuclear Engineering & Science Conference, the Atomic Energy Management Conference, and the Atomfair.

Features of the assembly will be engineering papers concerning advances in reactor technology and the use of radioactive materials, industrial management, and laboratory problems.

The theme of the congress is *For Mankind's Progress*. For further information write Engineers Joint Council, 29 W. 39th St., New York 18, N.Y. Members interested in a complete program can obtain a copy by writing to the Institute.

Demand For Scientific Executives Is Charted

The trend of American industry's needs for scientific-technical personnel has been charted in a report by Hoff, Canny, Bowen & Assocs. Inc. The purpose of the survey is to help corporations plan to meet their future executive needs. The study was conducted by Dorothy Gregg, research consultant, and was based on findings of 612 top industrial firms in the U. S. in April and May, 1958.

Highlights of the survey show a growing need for outstanding scientific technical executives. In the next year the greatest demand will be for chemists, industrial engineers, and mechanical engineers, with a lesser demand for petroleum engineers, geologists, and geophysicists.

But while the need is great, over three-fourths of the companies surveyed find it difficult to secure top personnel who are also strong in administrative skills. Over-specialization, lack of well-rounded education, lack of interest in administrative work are cited as reasons for the shortage.

More recently developed fields of chemistry, electronics, and atomic energy offer the greatest financial rewards at present. Other incentives include fringe benefits, pleasant working conditions, stock option plans, and opportunities for advancement. The possibilities for scientific jobs abroad are also increasing.

Promotion and selection have become highly skilled operations among top firms who utilize psychological testing services. Performance record is still the determining factor in promotions for 54% of the companies. But in the selection of new personnel increasing reliance is placed on executive recruiting organizations for high-salary positions. And over half of the companies use some pre-employment testing.

Other employment trends mentioned in the survey suggested that recessions do not affect the long-range demand for scientific personnel, and that opportunities for women in the field are increasing. Over half of the companies expressed willingness to hire women for their top positions if they are properly trained and qualified. Nevertheless 14% admit that they cannot hire women because "the male ego and the male feeling of superiority make this impossible."

One final area of opinion covered in the report was government subsidies for training technical personnel. Almost 60% of the companies feel that the government and public agencies should not subsidize talented high school graduates in their scientific college education. Instead 70% suggested that corporations should do their part to help students get the training they need.

Personals

Earl C. Payne, for many years a consulting engineer with Consolidation Coal Co., is president of Mineral Mills Inc., a new processor of magnetite in Pittsburgh. Mineral Mills has acquired the magnetite operations previously conducted by Orefraction Inc.

E. C. PAYNE

P. E. NEAMAN

Charles A. Wight was named president of Freeport Sulphur Co. and **Pearson E. Neaman** was made chairman of the executive committee in recent elections. Mr. Wight succeeds **Langbourne M. Williams** as president, while Mr. Williams retains his position as chairman of the board. Mr. Neaman, formerly senior vice president and general counsel, succeeds Mr. Wight as chairman of the executive committee. **Philip A. Lawrence** was elected vice president and controller.

Roy I. McIntosh, field service engineer for Boeing Airplane Co., has been sent to Chanute Air Force Base as senior field service engineer to assist in maintenance and operation of the new B52G, and to advise the Air Force concerning training with this model.

Jack B. Ward has been made vice president of Green River Oil Co. in Sante Fe, N. M. He had been general manager of Health Steele Mines, Newcastle, N. B., Canada.

Charles C. Cook, formerly chief minerals engineer for Heavy Minerals Co., now works for Vitro Uranium Co. as chief minerals processor in their diversification program in Salt Lake City.

W. J. Latvala, formerly mine superintendent, Consolidated Coppermines Corp., has become associate professor of mining engineering at the New Mexico Inst. of Mining and Technology. He will be faculty sponsor of the AIME student chapter.

John A. Shimer has returned to Brooklyn College, Brooklyn, after a sabbatical leave. He spent much of the past year in the Boston vicinity while working on a book on geomorphology. Mr. Shimer has taught geology for the past 12 years.

Charles Belt, Jr., is an assistant geologist for Mineraco Hannoca Litida, in Brazil where he is exploring for and mapping iron ore deposits. He had been a graduate student at Columbia University.

Ross W. Smith, formerly associate manufacturing process engineer for Portland Cement Assn., has accepted the position of project engineer for Colorado School of Mines Research Foundation.

G. S. Borden, who was special tax counsel for Standard Oil Co. of California, vice president and director of Mohave Mining and Milling Co., and Big Horn Mining Co., will devote a major portion of his time to mine explorations, development, and production. He is also president of Red and White Mining Co. and Virginia City Mining Co.

J. D. Bateman, formerly with Ventures Ltd. in Toronto, has become a consulting mining geologist there.

Earl O. Torgerson, consulting metallurgist of Salt Lake City, was named project manager for Utah Construction Co.'s Korean tungsten venture. Utah Construction Co. is contract adviser to the Korea Tungsten Mining Co., a Republic of Korea-sponsored firm.

R. LAWRENCE, JR.

C. S. WIGHT

M. W. Kellogg Co., New York, announced the appointment of **Robert Lawrence, Jr.,** as sales manager in charge of the new Hojalata y Lamina process which converts iron ore into sponge iron, using reformed natural gas as the reducing agent.

James E. Stocker has been appointed reduction plant maintenance superintendent of Ray Mines Div.,

personals

continued

Kennecott Copper Corp. Prior to joining Kennecott, he was chief electrical engineer for American Smelting and Refining Co. in El Paso. Now he will be located in Ray, Ariz.

J. D. Murdoch has been promoted from assistant mine engineer at Carlsbad, N. M., to assistant mine supervisor in Saskatoon, Sask., for the Potash Co. of America Ltd.

Takeshi Nagano, formerly research engineer, has advanced to assistant superintendent of the Copper Smelting Div., Mitsubishi Metal Mining Co. in Naoshima, Japan.

Thomas L. Wright, geologist for Aluminum Co. of America, will be exploring for deposits of bauxite near Moengo, Dutch Guiana, with Alcoa's Suriname subsidiary, Suralco.


J. W. WELDON


J. T. O'ROURKE

Albert P. Gagnebin was elected vice president and **Joseph M. Weldon** was elected assistant vice president of The International Nickel Co. Mr. Gagnebin had been assistant vice president and Mr. Weldon had been assistant to the vice president.

John T. O'Rourke has been appointed assistant vice president of Anaconda-Jurden Assocs. Inc., Anaconda Co. subsidiary. He had been a division engineer for Burns & Roe Inc., New York.

Lawrence J. Ingvalson, assistant general superintendent of the Great Falls, Mont., reduction works, has been advanced to the post of general superintendent. **Leonard C. Powell** has been named assistant general superintendent. **James L. Owings** succeeds Powell as development engineer. **Merrill A. Mosher** has been appointed manager of the

Raritan Copper Works of the International Smelting & Refining Co., an Anaconda subsidiary. **John M. Casteras** was named general superintendent to replace Mr. Mosher. **John P. Cooper,** assistant to the manager, retired in November after 45 years of service with the firm.

Robert G. Doyle was recently appointed geologist with the Maine Geological Survey. For the past five years he has been associated with St. Joseph Lead Co. in southwest Missouri. A graduate of Harvard College, he also spent several years in Peru as a field geologist.

R. G. DOYLE

J. S. SMART, JR.

New appointments at American Smelting and Refining Co. include **John S. Smart,** now general sales manager, and **Ralph L. Wilcox,** the new assistant sales manager.

Robert Hughes has been appointed director of research and development of Dravo Corp., replacing **W. L. Newhall** who has retired after 33 years of service. **John A. Anthes** was named assistant director of research and development.

Earl A. Bradley has assumed new responsibilities as vice president of National Mine Service Co., to supervise three manufacturing divisions: Ashland, Clarkson, and Greensburg. He had served as general manager of the Ashland Div.

Daniel L. Ziegler, project manager at Alpha Portland Cement Co., was appointed assistant to the vice president for operations.

George W. Streepey is now general manager of Aluminum Co. of America's raw materials division. Formerly called the mining division when it was concerned primarily with that operation, this unit has charge of such additional activities as exploration for and development of oil and gas, minerals, and fuels, and so has been renamed the raw materials division.

Peter S. Jack has been promoted to the newly created position of general refinery foreman at Potash Co. of America's refinery at Carlsbad, N. M. He had been metallurgical engineer.

Gene Dale, who has been assistant superintendent of Potash Co. of America's refinery in New Mexico for almost two years, is leaving for

personals

continued

Canada as surface superintendent of the Canadian firm, PCA Ltd.

W. Rodney DeVilliers has been elected senior vice president, and **Nels W. Stalheim,** vice president, of New Hidden Splendor Mining Co.

A. T. Newell retired in January as works manager for Stauffer Chemical Co., Henderson, Nev. after service in that position since 1946. **J. F. Orr,** his assistant, became the new works manager.

Robert B. McKeagney, managing engineer for The Asphalt Inst., New York, has taken the position of field engineer for the New Haven Trap Rock Co. in Connecticut.

Samuel H. Dolbear and **Parke A. Hodges** of Behre Dolbear & Co. have been in Europe on a professional mission in England, France, Germany, Denmark, and Sweden.

Albert C. Whitaker, Jr., has been appointed director of iron ore procurement, Wheeling Steel Corp. He has been assistant director since 1955.

H. FREYENSEE

L. C. BLACK

Howard Freyensee has been appointed manager of sales, large excavators, by Bucyrus-Erie Co., South Milwaukee, Wis. He succeeds **Lewis C. Black,** who has been named manager of domestic sales.

R. A. Elliott, formerly assistant director in the Dept. of Engineering and Metallurgy, Ontario Research Foundation, has become a partner in the firm of Ensio, Whiton and Assocs. Ltd., mine, mill, and smelter engineers in Toronto.

Edmund L. Dana, district manager for E. I. du Pont de Nemours & Co., Explosives Dept., Scranton, Pa., is now in Duluth.

Carl E. Mills has retired as manager of the Copper Queen Branch and Douglas Reduction Works, Phelps Dodge Corp. He also retired as director of the AIME Arizona Section, the Arizona Chapter of the American Mining Congress, and the Bisbee Chamber of Commerce.

W. H. H. Cranmer, president of New Park Mining Co., was presented the Award of Distinguished Citizenship at the 100th anniversary of the founding of the city of Denver.

Robert W. DeMott, who has been district sales engineer for the Chain Belt Co. in the Philadelphia and Lehigh Valley area since his service in the Korean War, has been transferred to Los Angeles as district sales manager.

Tom T. Heywood, formerly mining engineer for Eastern Mining & Metals Co. Ltd., now is mine superintendent of Sematan Bauxite Ltd., British Borneo.

R. L. Miller is a sales engineer for Eimco Corp., Palatine, Ill. He had been a student at the Missouri School of Mines & Metallurgy.

Bruce E. Russell, geological engineer, formerly with Exploration Services in Denver, has joined E. J. Longyear Co., Grants, N. M., to do exploration work on San Mateo Dome, N. M.

Brinton C. Brown, Ideal Cement Co., has been promoted from plant engineer to general foreman, and

transferred from San Juan Bautista, Calif., to Trident, Mont.

Paul O. Hamer, mining engineer, spent 4½ years as an advisor to the Engineering Staff of the Royal Afghan Ministry of Mines and Industry in general mining work, with an emphasis on coal. Noteworthy improvement during his service in Afghanistan was made in health, safety, and medical services benefiting mine personnel and their families. He represented the U. S. Bureau of Mines, and now is in the Div. of Foreign Activities, in Washington, D. C.

Gene Bishopp, Boulder, Colo., returned from a mine examination trip to northern Mexico and has left for Guayaquil, Ecuador, on a consulting basis to work with Constructora Nacional de Carreteras S. A.

C. F. Clausen, director of manufacturing process, Portland Cement Assn., Chicago, addressed the 41st anniversary convention of the National Coal Assn. on the subject *Present and Future Energy Requirements of the Cement Industry.*

Greg V. Parker has become shift foreman for Andes Copper Mining Co. in Potrerillos, Chile. He had been an engineering trainee for Anaconda in Butte, Mont.

Wallace F. Boyd, formerly geologist for Heinrichs Exploration Co., now is computer programmer trainee for System Development Corp., Santa Monica, Calif.

R. C. MEADERS

W. WRAITH, JR.

Robert C. Meaders, formerly vice president of Aerofall Mills Inc., Columbus, Ohio, has moved to Milwaukee to be assistant manager of the mining, crushing, and process machinery division of Nordberg Manufacturing Co. Simultaneous with this appointment, **D. A. Cheyette,** division vice president, was named executive director at Nordberg and **Jack B. Bond** was promoted to general manager of this division.

Russel B. Caples, who is vice president of The Anaconda Co. will coordinate and supervise company aluminum interests. **William Wraith, Jr.,** has been advanced to the newly created post of metallurgical man-

R. B. CAPLES

T. K. GRAHAM

ager. **Thomas K. Graham,** who has been manager of the Raritan Copper Works, has been advanced to the position of assistant metallurgical manager of Anaconda.

P. K. Edwards, formerly plant engineer for Michigan Silica Co., now is plant superintendent for Sewanee Silica Co., Tenn.

Derrell D. Piper graduated from the University of Minnesota and is now employed by Ingersoll-Rand Co. in Phillipsburg, N. J.

Donald Bonomer is now employed by Bethlehem Cornwall Corp. in Cornwall, Pa.

J. D. McLehaney, Jr., completed scholastic requirements for the master of science degree in mining engineering from the University of Arizona and accepted a position with Shell Oil Co. He will be in the training program in the West Coast area, with headquarters in Oildale, Calif.

personals

continued

Harold J. Rose, vice president and consultant, Bituminous Coal Research Inc., Pittsburgh, has been awarded the Worcester Reed Warner Medal of ASME. This is a medal for outstanding engineering literature, earned by Mr. Rose for the 90 papers he has written, mainly on coal and coke research. A second ASME literature medal, the Melville Medal, was awarded to **Thomas P. Goodman,** kinematics engineer for the General Electric Co.

G. B. O'Malley, who has been with Cyanamid Australia Pty. Ltd. for 19 years, has been appointed acting managing director of the American Cyanamid Co. subsidiary.

David H. Orr, Jr., Phelps Dodge Corp., has advanced from chief engineer to mine superintendent at the Morenci Branch.

James A. Whelan is an assistant professor of mineralogy at the University of Utah in Salt Lake City.

R. S. A. DOUGHERTY

E. GAMMETER

Robert S. A. Dougherty, former manager of research for the Bethlehem Steel Co., has joined the Philadelphia management consulting firm of Mayer and Dibrell and Co. Inc. He will act as resident manager, Lehigh Valley, for the firm.

Erwin Gammeter, a vice president of Paul Weir Co. Inc., Chicago, has assumed new duties as department head of the company's coal mining mission in South Korea. He has represented the company on coal mine development programs in Turkey and Brazil.

C. O. Mittendorf has resigned his post as administrator of the Office of Minerals Exploration with the Dept. of the Interior to accept the position as director of industry and transportation for the mission to Iran of the International Cooperation Administration. Mr. Mittendorf had come to the department on loan from the Economic Cooperation Administration where he had directed mission operations in Turkey.

Herbert C. Hoover, Jr., consulting engineer in Los Angeles, and former U. S. Under Secretary of State, has been elected a director of Lockheed Aircraft Corp.

Ivor G. Pickering, project manager, Kennecott Refining Corp., is working on the new electrolytic copper refinery being built south of Baltimore by M. W. Kellogg Co. of New York.

Clyde Williams of Clyde Williams and Co., Columbus, Ohio, spent six weeks in Europe this fall on a business trip.

H. R. Heydegger, formerly a physical chemist at the Petroleum Experiment Station, U. S. Bureau of Mines, is now research assistant for Enrico Fermi Inst. for Nuclear Studies, University of Chicago. He received an M.S. in chemistry at the University of Arkansas and is continuing studies for a Ph.D. in nuclear geochemistry at the University of Chicago.

Robert Huebner, who was a junior mining engineer for International Nickel Co. of Canada Ltd., is now civil engineer for Allied Engineers, Topeka, Kan.

J. H. Valkenhoff, who has been chief engineer of the Quiruvilca Unit, Northern Peru Mining Corp., for six years, has accepted a position with Suriname Aluminum Co., a subsidiary of the Aluminum Co. of America, at the company's Brokopondo project in Surinam, Dutch Guiana.

Evan Just, formerly vice president of Cyprus Mines Corp., is now president of International Drilling & Water Co. Inc. in New York. He is also available as geological and exploration consultant.

J. S. Mitchell, manager of the Garfield cobalt refinery of Calera Mining Co., has been named superintendent of the pilot plant division of the Nickel Processing Corp., Nicaro, Cuba.

R. H. Ganz of Gardner-Denver Co., who had previously directed the company's sales and service operations in Toronto, and was district manager in New York, now has been appointed general sales manager with headquarters in Quincy, Ill.

Arthur T. Griffis, formerly manager of Oceanic Iron Ore Co., Rio Tinto Management Services, is now research geologist for McIntyre Porcupine Mines Ltd.

Gene E. Congdon has been promoted to the position of geophysical computer for the El Paso Natural Gas Co. He had been junior geologist for their subsidiary, Rare Metals Corp. of America.

A. W. Allen has left the tunnel job at Faraday, Estacada, Ore., to accept the position of engineer with Northwood Inc. of Vancouver. He will be working on a project of the Vandenburg Air Force Base in California.

William A. Griffith, formerly metallurgist for Rare Metals Corp. of America, is now research engineer for Phelps Dodge Corp. He will be in the Morenci, Ariz., branch.

Richard C. Ely has become geologist and engineer for Ely & French, geologists. He had been a student at the University of Pittsburgh.

J. Reysenbach, formerly mill superintendent of Uis Tin Mining Co. Ltd., South Western Australia, now is technical assistant for Union Corp. Ltd., South Africa.

Richard W. Clark has left Braden Copper Co. where he was junior metallurgist, for the position of associate engineer for Boeing Airplane Co.

W. B. Foster, mine superintendent, has left Pend Oreille Mines & Metals Co., Metaline Falls, Wash., to join Kermac Nuclear Fuels Corp., Grants, N. M.

E. M. Lindenau, formerly associated with Compania Minera Choce Pacifico in Colombia, is now manager for Gibralter Minerals Co. in Kayenta, Ariz.

Thomas Cox, Honor Roll Member 1901, might appreciate hearing a word from his pals all over the Institute. He has lost touch with the world since he has become paralyzed and blind, but is still deeply interested in mining affairs and news of his fellow AIME members. He can be contacted at his home, 463 Ellita Ave., Oakland, Calif.

Harry F. McFarland, *consulting mining engineer of Denver, is shown with his third-year students in Rangoon, Burma, where he is teaching mine engineering at the Government Technical Inst., for the International Labour Office there.*

Obituaries

Roy E. O'Brien

An Appreciation By
Andrew Fletcher and Henry D.Smith

If we were to outline all the desirable qualities and background which a field secretary of the AIME should possess, we could find no finer example than the background and character of Roy E. O'Brien, who died in Salt Lake City on January 9, 1959. Born in the west, in Victor, Colo., on July 3, 1898, he received an A. B. degree from the University of Colorado in 1923. He did not plunge immediately into mining but used his talents to sell Studebaker cars in Colorado. However, we imagine, coming from a mining family, mining was in his blood, for Roy next took a job as mine engineer for Cananea Consolidated Copper Co. in Mexico, and in turn became mine shift boss, division foreman, and assistant foreman. He then transferred his energies to the Mountain City Copper Co., remaining 13 years with this organization until 1949, and ultimately becoming mine superintendent and superintendent at Mountain City and Rio Tinto, Nev. His next change was to phosphate mining as general foreman of Anaconda's phosphate operations at Conda, Idaho. Unfortunately, however, a heart condition compelled him to relinquish his active mining career in 1950.

It was, therefore, AIME's good fortune to be able to appoint him western secretary of the mining branch on Sept. 1, 1950, with an office in Salt Lake City, and simultaneously, assistant secretary of the Institute. In 1953, the title of western secretary of the mining branch was changed to field secretary.

All of Roy's background stood him in good stead in his official capacity as field secretary. His friendliness, his understanding of the problems of the profession, his ability to get along famously with people and his many dealings with the public, which are the lot of any mining manager, were qualities that served him and the Institute admirably. Hundreds of his friends throughout the country, and particularly in the western local sections of the AIME, will remember him with affection and as a valuable friend and counselor. They can attest to his warm personality and willingness to help make the AIME an indispensable organization for the profession.

Despite the handicap of a health which was none-too-robust, he injected his own love of mining and his devotion to the Institute into all of the areas in the west which he so ably served. One need only turn to the growth of western membership as ample proof of the successful discharge of his responsibilties.

His host of friends all over will miss his genial presence at AIME conventions and local affairs and they will mourn the loss of one who helped to maintain the high professional standing of the AIME so superbly. But, they have one consolation. He has left behind his devoted wife, Lee, who is equally enthusiastic about mining and the ideals of the Institute. In fact, one cannot think of Roy and his work without thinking equally of the energy and devotion of Lee O'Brien for our Society.

Lauren A. Gates

An Appreciation By
Lloyd G. Fitzgerald

Lauren A. Gates (Member 1941) died in Beckley, W. Va., Nov. 24, 1958, after a short illness. Born in Pine Grove Mills, Pa., on Feb. 15, 1887, he naturally turned to civil and mining engineering as a profession and thought and dreamed engineering. Gates came to Beckley, W. Va., in 1920 and joined the E. M. Merrill Engineering Co. Beckley is the center of the famous Smokeless Coal Field. In recent years Gates and his son Leslie C. Gates operated the concern under the name of Gates Engineering Co.

Mr. Gates was active in many professional organizations. He was a member of the West Virginia Society of Professional Engineers and was a registered engineer in both West Virginia and Kentucky. Gates was listed in *Who's Who in Engineering*.

He was also active in church and civil organizations. A member of the Beckley Presbyterian Church, Gates served as an elder for the past 30 years and as secretary of the Sunday School for 19 years. He belonged to the Beckley Masonic Lodge No. 95, Beckley Elks Lodge No. 1452, and the Black Knight Country Club.

The value of the 38 years during which Lauren A. Gates lived in the community was ably expressed in the local Beckley newspaper, the Post-Herald:

"A resident of Beckley for 38 years, Lauren A. Gates was a quiet and unassuming man whose influence was always for the good of the community. He was never in any way flamboyant but was instead steady and purposeful in his actions. . . . Upon his death there was before his fellow citizens an example and a record to be sought by lesser men."

John P. Skinner (Member 1930) was killed in a mining accident in Treadway, Tenn. Born in Prattsburg, N. Y., in 1917 and a graduate of the University of Illinois in 1939, he began his engineering work as a mucker for The London Mines and Milling Co. and then as a mine engineer in Alma, Colo. In 1941 Mr. Skinner was a bit and steel engineer for Climax Molybdenum Co. During World War II in the Army Air Force, he became assistant engineering officer, then engineering officer on B-24 airplanes, leaving the service as a captain. He joined The New Jersey Zinc Co. as surveyor in 1945 and became assistant mine foreman and was sent to Gilman, Colo., in 1949 where he advanced to mine foreman. He was transferred to Treadway in 1957.

Charles E. Taylor (Member 1950) died on June 21, 1958. He was born in 1885 in Appomatox, Va., and in 1902 started to work for the Bertha Mineral Div. of The New Jersey Zinc Co. at Austinville, Va. He was graduated from Virginia Polytechnic Inst. with the class of 1913 and resumed employment at Austinville. He became superintendent of the Bertha Mineral Div. in 1927 and held that position until 1946 when he moved to Palmerton, Pa., to work in the Research Dept. of the company. Mr. Taylor did work in the field of mineral dressing which he continued until his retirement in 1955.

George R. Rogers (Member 1914) died on Dec. 6, 1957. Born in New South Wales, Australia, in 1877, he attended school there until 1892 and then began work at Rivertree silver mines as an assayer's assistant. In 1897 he studied mining engineering and surveying under Edgar Halt, then went to Brisbane Technical College and Balbareth School of Mines. In 1893 he was in charge of the mill and cyanide plant of Big Hill Gold mines, later leaving Australia for South Africa. Mr. Rogers later went to Canada, becoming general manager of mines in Cowganda, Canada. He lived for several years in Toronto, before settling in Salida, Colo., where he was associated with Salida Limerock Co.

John B. Platts (Member 1924) died on Mar. 3, 1958. He was born near Salem, Ore., in 1881, and graduated from the University of Oregon. His varied career began in prospecting and mining; later he operated a custom assay office in Crescent City, Calif., and then did tunnel contracting, before going to Alaska. Mr. Platts was active in assaying and surveying, prospecting, and operating mines and mills throughout the west. In 1923 he was assistant superintendent for Ibex-Bay Mining Co. He spent many years in Wallace, Idaho, prior to his death.

Gerald F. Sherman (Legion of Honor Member 1903) died on May 20, 1958, in Balboa, Calif. A native of New York, he graduated from Columbia School of Mines in 1894, and began

his career as assistant engineer in Idaho. Mr. Sherman did some work for the U. S. Geological Survey, and held positions as accountant and assistant superintendent in Grass Valley, Calif. In 1920 he was civil and construction engineer for Phelps Dodge Corp. at the Copper Queen Mine in Bisbee, Ariz. In 1931 Mr. Sherman was consulting mining engineer for the Philadelphia & Reading Coal & Iron Co. in Ashland, Pa. Later he served as a consultant in New York.

Elliott Check (Member 1941), mining engineer and resident of Atherton, Calif., for the past 16 years, died on Oct. 26, 1958. He had maintained offices as a consulting engineer in San Francisco for 30 years. He was listed in *Who's Who on the Pacific Coast.* Born in Raleigh, N. C., he attended Stanford University and two mining schools in the Southwest. During World War I he served in the army as a second lieutenant and was under the command of Lt. Col. Dwight D. Eisenhower in the tank corps in World War II.

Roy L. Cornell (Member 1942) passed away in Los Angeles, where he was vice president of California Testing Laboratories Inc. Born in Summertown, Tenn., in 1881, he attended the University of Arizona and the University of California. His varied jobs included metallurgist in charge of smelter for Troy Manhattan Copper Co., assayer and prospector in Nevada, engineer and *chef de mission* in the Belgian Congo, Africa, and resident engineer for Standard Minerals in Arizona.

Stewart J. Cort (Member 1948) died in Bethlehem, Pa., on Sept. 23, 1958. He had recently retired as vice president in charge of the steel division of Bethlehem Steel Co. A native of Illinois, Mr. Cort graduated from Lehigh University and began his steel career with the Carnegie Steel Co. He was given an honorary degree from his alma mater and was the first recipient of the Benjamin F. Fairless Award of AIME in 1953. He had joined Bethlehem Steel in 1917 as superintendent of the open hearth department and was named vice president in 1947. In addition, he was an elder of the Presbyterian Church for more than 50 years and had been a leader in civic and philanthropic activities.

Collis E. Druley (Member 1940) died on June 27, 1958. He was born in Iowa in 1903 and attended Prescott High School, Stout Inst., and New Mexico School of Mines, where he received a B.S. in mining engineering. He was an instructor in general metal work, then a miner, timberman, and assistant foreman. In 1936 he went to Alaska for the Alaska Juneau Gold Mining Co. where he became shift boss. His other positions included vice president of United Supply Co. in Portland and engineer in Oswego, Ore.

John A. Hammond (Member 1949) passed away on Feb. 1, 1958. A native of Camden, S. C., he graduated from Clemson College in 1920 and went to work for Westinghouse Electric Corp. He completed a technical training course at East Pittsburgh and South Philadelphia Works and was assigned to the New Orleans office as technical salesman. He joined National Carbon Co. Inc. in 1923 and became Pittsburgh division manager. Later he was appointed district manager for the National Carbon Div. of Union Carbide & Carbon Corp.

Harry A. Harper (Member 1952) was born in 1888 in Ironwood, Mich., and died June 14, 1958, in Oreville, Calif. He attended Michigan College of Mines and became a chemist for Castile Mining Co. Consulting work took him to Chile, Bolivia, Argentina and Peru. He traveled from South America to Europe before returning to the U. S. as foreman for Utah Construction Co. in Summit, Calif. For several years he worked for investment firms, reporting on mining properties all over the western states. In 1951 he was coordinator, South Fork Feather Power Project.

Henry Krumb (Member 1905) was born in Brooklyn in 1875 and died in New York City on Dec. 27, 1958. He was a graduate of Columbia University and received an honorary doctorate from the School of Mines in 1951. Mr. Krumb was best known for his original examination of mines producing the porphyry coppers. He was a director of many mining companies in Alaska, Canada, Mexico and the U. S. During World War I he served on the priorities committee of the War Industries Board. Among the many honors he has received is the Egleston Medal for engineering achievement.

Necrology

Date Elected	Name	Date of Death
1944	Alfred T. Anderson	Nov. 9, 1958
1957	Rush Bailey	Apr. 21, 1958
1953	Russell C. Barbour, Jr.	October 1957
1914	Harold L. Batten	July 9, 1958
1905	Alfred L. Blomfield Legion of Honor	Oct. 19, 1958
1942	Clarence L. Corban	May 1958
1914	Clinton H. Crane	Dec. 1, 1958
1939	Ephraim B. Daggett	Oct. 28, 1958
1945	John R. Drenan	July 14, 1958
1940	Russell C. Fish	Nov. 12, 1958
1941	Lauren A. Gates	Nov. 24, 1958
1948	Edwin T. Goodridge	Nov. 20, 1958
1916	Robert E. Hobart	June 1958
1946	John W. House	Oct. 10, 1958
1951	John J. Inman	May 10, 1958
1917	Curtis Lindley, Jr.	February 1958
1917	James O. Lord	Oct. 13, 1958
1956	Richard C. Lundin	Nov. 13, 1958
1924	James T. MacKenzie	Nov. 17, 1958
1952	John L. Martin	Mar. 22, 1957
1940	William J. Morrow	Aug. 23, 1958
1944	Herbert D. Nelson	Sept. 30, 1958
1917	Philip E. Nolan	Nov. 28, 1958
1948	Harry H. Nowlan	Nov. 20, 1958
1937	Roy E. O'Brien	Jan. 9, 1959
1904	George W. Paymal Legion of Honor	Mar. 30, 1958
1956	Warren M. Peterson	Aug. 19, 1958
1914	Curtis Pigott	Nov. 29, 1958
1950	Frank F. Poland	Nov. 16, 1958
1897	Herman A. Prosser Legion of Honor	Nov. 22, 1958
1946	Otto Ruhl	June 21, 1958
1949	Charles E. Shilcutt	Nov. 1, 1958
1921	Joseph L. Shugert	Mar. 21, 1958
1915	Frank H. Skeels	Nov. 20, 1958
1920	William H. Stewart	Aug. 7, 1958
1937	Henry R. Wardwell	Nov. 15, 1958
1950	Charles O. Willson	Sept. 19, 1958

Membership

Proposed for Membership
Society of Mining Engineers of AIME

Total AIME membership on Sept. 30, 1958, was 30,654; in addition 3,131 Student Members were enrolled.

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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